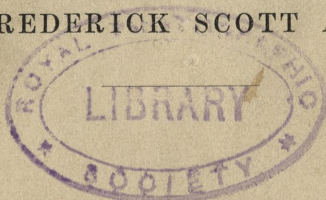


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THE
COLLODION PROCESS
ON
GLASS.

BY FREDERICK SCOTT ARCHER.



Second Edition, enlarged.

LONDON:
PRINTED FOR THE AUTHOR,
105, GREAT RUSSELL STREET, BLOOMSBURY.

1854.

ENTERED AT STATIONERS' HALL.

THE

COLLUSION PROCEEDINGS

GLASS.

OF THE HOUSE OF COMMONS

AND THE HOUSE OF LORDS

IN THE

REVENUE COMMISSIONERS

AND THE HOUSE OF COMMONS

LONDON :

A. SWEETING, PRINTER, BARTLETT'S BUILDINGS, HOLBORN.

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INTRODUCTION.

THE power possessed by solar light, and in a less degree by artificial light, in producing chemical change in the various organic and metallic compounds of the earth has been long known, and excited the attention of the most able chemists and philosophers of the day.

For several centuries the darkening effect of the solar rays on chloride of silver has been remarked.

More recently, Sir Humphrey Davy and Mr. Wedgwood turned their attention to this curious subject, and endeavoured, but without success, to apply it to useful purposes. They were stopped at the very commencement of their inquiries, by the want of a fixing agent, to prevent any further change taking place on the prepared surface employed, after the required effect had been produced. They were unable to overcome this difficulty, and consequently abandoned the pursuit. Although the progress of the inquiry was checked by this difficulty, it was not entirely abandoned; for, after much labour and patient investigation, means were found to prevent the action of light

beyond the desired point. Without this power, the entire labour would be thrown away, for the impression received would quickly disappear in the general darkening of the whole surface.

From these small beginnings, a new Art has been discovered, beautiful in its results, commanding equally the attention of the artist and the man of science.

The chemical philosopher will find in it a new study, and wide field of research open to his view; presenting, in fact, an entirely new branch of chemical inquiry; and he cannot fail to be struck with the great power which a very feeble ray of solar light possesses, in producing a rapid chemical change in some bodies when presented to its influence, the consideration of which may induce him to devote some portion of his time to the investigation of a subject, so interesting in its details and marvellous in its effect.

He will also observe how very large a portion of the solar rays, though not absolutely necessary to illuminate and brighten the face of the natural world, are not less essential to our well-being, and are silently working with powerful effect in producing remarkable changes, and modifying by their influence the most enduring, as well as the most fragile, of nature's productions.

The artist will avail himself of Photography for noting down the aspect and changes which are constantly varying the face of nature, opening to his observation many striking effects of light and shadow, which, without its aid, would altogether escape his observation, or elude the vigilance of his pencil to note down. To him it will prove a valuable assistant in abridging the labour in collecting sketches of various objects of

interest, the minute details of which he might be anxious to obtain, but which would encroach too much on his time and patience, if obliged to have recourse to his pencil to delineate them.

Although the great precision and minuteness of detail of the impression produced on the prepared plate would go far beyond his ideas of what is absolutely required of him to be produced with his pencil, still he has the power, when assisted by a proper judgment, of omitting in his finished productions such details as are not necessary to produce the effect he desires.

It must not be imagined that photography can ever take the place of the painter's art in its higher branches, as more likely to give faithful portraiture and correct ideas of character and expression.

In Portraiture, for instance, the artist will seek for a certain and well-known expression characteristic of his sitter, without which, he well knows, that his picture, although conveying every other detail with correctness, would be a failure. On the other hand, what photographer has not observed how the various impressions he has taken of the same features, perhaps in succession, vary considerably, without any of them representing fully the characteristic expression of the sitter? In this point of view, it will be seen, that photography is widely separated from art, and cannot easily accomplish all that is required at the hands of the artist.

The process with Collodion was originally given by me in the March number of the *Chemist*, 1851; and I had in a previous communication to the same journal made known the great power of pyro-gallic acid as a developing agent.

Since their introduction, photography has made most rapid strides towards perfection, various improvements have been suggested in its manipulation, all tending towards the ultimate perfection of the process; and it will be my aim in the present Manual to describe such improvements as I consider essential, and worthy to be adopted by the photographer.

It will be as well to say a few words in reference to the various experiments which led me to adopt collodion as a medium, so well adapted for receiving the chemical agents necessary in this beautiful art.

In my first account of the Collodion Process, I alluded to the difficulties attending the use of paper, and described them as being too great ever to be overcome, on account of the unevenness of its texture and other defects.

My first attempts with collodion were directed to the improvement of the surface of paper, by spreading over one side a thick solution of collodion.

These essays were not successful, for, after the necessary washing, &c., in the process, the collodion film did not adhere to the paper sufficiently to be of any use.

However, previous to and during the progress of these experiments, I was trying various other substances as media, for holding the chemical agents—zyloidin, other modifications of starch, extremely fine paper pulp, tanno gelatine solutions, and several combinations of albumen. Each had its turn, and it was only after innumerable experiments in various ways that I decided on collodion as being the best, and, at the same time, the most available substitute for paper. Its exceeding ease of manipulation, and the brilliancy of the pictures obtained

with it, cannot fail to strike every one who sees them; and justifies me in the opinion I entertain of its value and practical importance.

With regard to the introduction of collodion as the foundation of the process, I must say a few words.

Collodion, there is no doubt, early attracted the attention of photographers, but who first actually suggested its use, we have no means of determining with any precision; since however its value as a photographic agent has been known and appreciated, many claimants have come forward anxious to obtain a share in the merit of its first introduction.

There can be little doubt that many of those engaged in the pursuit of photography, anxious to improve the then known processes or invent others, would very soon have collodion brought under their notice, proceed to test its capabilities as a photographic agent, and possibly endeavour to work out a process by which it could be made available in the art.

It is indeed obvious, from a consideration of its remarkable qualities, that it could not long escape their observation, and we may easily imagine also that it would be likely to attract simultaneously the attention of many parties who were labouring in the same field of research.

It is evident that, in deciding a question of this kind, the *first published account* must take precedence of any other kind of proof, and it is due to M. Gustavus le Gray, a gentleman whose great services in other branches of the art of photography are well known, and are held in high regard, to say that he was the first to publish an account of collodion as a photographic agent. I allude to his pamphlet published in 1850, wherein he mentions collodion and its *possible* use.

His first application of it appears to have been as an encollage for paper. Afterwards he used it on glass, and gave in his memoir a short account of his researches, but no manipulation in detail was made known, such as would entitle it to be called a photographic process; and from the wording of his published notice, it would appear to have been merely an extract from his note book of chemical experiments; as such it attracted little attention at the time; still M. le Gray must be considered the first party who, by publication, made known his researches on the subject, and although this notice did not lead to its practical use, it establishes his claim to be considered the first to suggest its value in photography.

About the month of June, 1849, I began to turn my attention to collodion as a substitute for paper, with the hope that by its means a surer and more delicate medium might be produced to work upon than paper was ever likely to be.

I tried numberless experiments with it, and varied the mode of using collodion, with the hope of getting at a practicable and sure method of working it.

These experiments were carried on until the month of March, 1851, when I published in the "Chemist" a short account of my experience in the matter; giving a process in detail,—the mode of preparing collodion with iodide of potassium and silver—the proper strength of the nitrate of silver bath—the best proportion of pyro-gallic acid for developing the latent picture, with the manner of fixing the picture produced; in fact, giving the whole of the process in detail.

It will therefore be evident, that although M. le Gray has the merit of having been the first to make known this valuable photographic agent, still as he did not, at the time of his publi-

cation, produce it as a process with the necessary details to make it intelligible to the photographer, his claim must in consequence be limited, and cannot in justice interfere with the merit of another party, who, from his own experience, made known a process with collodion, and that *without any assistance* from, or reference to, the labours of others in the same field of research.

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June, 1854.

action, produce it as a process with the necessary details to make it intelligible to the photographer; his claim must in consequence be limited, and cannot in justice interfere with the merit of another party, who, from his own experience, made known a process with collision, and that without any assistance from, or reference to, the labours of others in the narrow field of research. It is not a commendable practice to state that

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COLLODION PROCESS

ON

GLASS.

PART I.

PREPARATION OF MATERIALS.

GUN-COTTON.

THIS remarkable substance was first brought to the notice of the scientific world by Schönbein, who obtained in this country a patent for his invention.

Its applicability as an explosive substance does not appear to have realized the expectations of its promoters, and little is now heard of it as a substitute for gunpowder.

It appears that the explosive properties of ligneous substances when submitted to the action of nitric acid, was known some time previous to the introduction of gun-cotton by Schönbein.

The Photographer, however, applies this substance to a more peaceful, and, I should hope, a more useful purpose than that contemplated by its inventor.

Gun-cotton is formed when carded cotton, flax, or any other form of woody fibre, is submitted to the action of nitric acid ; it is, in fact, a combination of wood-fibre with a certain proportion of the nitrogen of the acid. In order that this combination may take place, the nitric acid must be in what is called the nascent state, free to combine. For this purpose, a mixture of sulphuric acid and nitrate of potass, or sulphuric acid and nitric acid, are mixed in certain proportions. The nitrate of potass, or nitric acid, is im-

mediately decomposed by the sulphuric acid, giving rise to the formation of nitric acid vapour, which at the moment of its formation combines in certain proportions with the cotton fibre, producing thereby the explosive substance called gun-cotton.

It appears that gun-cotton is composed of two distinct, though analogous substances; one is called pyroxylin, leaves no residue on explosion, and is not soluble in ether—the other zyloidin, leaves a residue on explosion, and is soluble in ether.

The latter substance is produced by the action of the strongest nitric acid on starch or gum, which dissolves them into a thick mucilaginous liquid, precipitated by water, soluble in alcohol, and very soluble in glacial acetic acid; it in fact forms, with acetic acid, a hard and beautifully transparent varnish.

I have used this solution as a vehicle for holding the iodide of potassium, when endeavouring to form a sensitive medium on glass. It answered to a degree. It was one of my earliest experiments, but was abandoned for collodion.

It may be remarked, that collodion cannot be made with zyloidine alone; it forms no coherent film when dried on glass from its solution in ether, consequently it is a misnomer to call iodized collodion zyloidide of silver, when the zyloidine it contains is only one of its component parts.

I shall give several receipts for making gun-cotton, from either of which a good dissolving cotton may be obtained. Many methods have been given, but I should only be confusing the subject to attempt to give the whole; and it would be foreign to the limited purpose of this work to do so.

The results, however, in regard to the solubility of the product vary so much with the strength and proportion of the acids used, as to render it extremely difficult to name any one mode in particular which would entirely succeed under all circumstances. In all cases it will be found more easy to prepare a cotton which

will explode readily, and yet be only partially soluble, than one which will entirely dissolve in sulphuric ether.

Take of	Nitre, in powder, dry . . .	40 parts
	Sulphuric acid . . .	60 ,,
	Cotton . . .	2 ,,

The nitre, sulphuric acid, and cotton, are weighed in the above proportions, and placed near at hand within reach of the operator, to prevent delay in mixing when the operation has commenced. First, put the powdered nitre into a basin placed firmly, so that there shall be no fear of its upsetting, then pour the proportion of sulphuric acid on the powdered nitre, stirring them well together with a strong glass rod for a few seconds.

Immediately the two are mixed add the cotton, having previously pulled out the fibres, and mix them well together with two glass rods, in order that the whole of the cotton may come in contact with the nitric acid vapour, which is being rapidly formed from the mixture. This action must be continued for about two minutes, then remove the cotton quickly from the basin with the glass rods, and plunge it into a large quantity of water; it must be well washed in repeated changes of water, until all the acid and nitre are washed away.

The cotton is then collected together, and first pressed between the hands to drain off the water, and then still further dried by pressure in a cloth; the fibres of cotton can now be carefully separated, and hung up with pins to the edge of a shelf, or any other convenient place, to dry. There is no necessity to use artificial heat, as the small quantity requisite for a few ounces of solution can easily be dried without it.

It is necessary that this operation should be conducted either in the open air, or in some convenient situation where there is sufficient draught to carry off the nitric acid vapour generated.

The next receipt is by certain proportions of nitric and sulphuric acids. Take

1 oz. by measure	Nitric acid	Sp. G. 1.4500
1 oz. ,,	Sulphuric acid	ordinary.
80 grs. by weight	Cotton.	

The fibres of cotton must be well separated, as in the preceding mode. The two acids are first mixed, the requisite proportion of cotton added as quickly as possible, and well stirred with the aid of two glass rods until the cotton is thoroughly saturated. The cotton may remain ten minutes, or even longer, in contact with the acids; it is then removed, and plunged into water to undergo the same washings, &c., as in the former recipe.

Water must not be spared in washing the cotton, for not a trace of acid should be left; the collodion would be injured by any remaining.

Or the following—

$\frac{1}{2}$ oz. by measure	Nitric acid	Sp. G. 1.4500
$\frac{1}{2}$ oz. ,,	Nitrous ditto	
1 oz. ,,	Sulphuric acid	ordinary
80 grs. by weight	Cotton.	

The two first acids are mixed, and the sulphuric acid added afterwards. The manipulation is the same as with the preceding formula.

A soluble cotton cannot be prepared with the strongest nitric and sulphuric acids, but a most explosive gun-cotton is obtained. This shows that a certain proportion of water is necessary to produce a soluble gun-cotton.

When, therefore, an explosive but insoluble cotton is the result of the operation, it may be taken as a sure indication that the acids have been used too strong, and require dilution. If, however, the product is neither explosive nor soluble, it shows that the mixed acids have been too weak, and unable to produce the requisite change. The remedy, therefore, in the latter case, lies the other way.

It is only by experiment that the proper strength of the acids can be ascertained with precision.

If, therefore, it is not shown with certainty the result likely to be obtained by a mixture of the two acids, a small quantity of each, equal volumes for instance, should be mixed, and a portion of cotton added, the immersion being continued for three or four minutes; after washing and drying the cotton, test its solubility in ether; if it should be found entirely insoluble, but very explosive, make a fresh mixture, adding for trial a quantity of water a quarter of the bulk of the mixed acids; add the water to the sulphuric acid first, then the nitric acid.

Immerse a small quantity of cotton for the same time as in the previous experiment, and if, after washing and drying, the cotton is found to be insoluble, and not explosive, it may be taken as an indication that too much water has been added. Having got these two data, giving the two extremes, little difficulty will be experienced in getting at the right proportion for the third trial.

For the first trial, take

1 dr.	Sulphuric acid
1 dr.	Nitric ditto.

For the second trial, take

$\frac{1}{2}$ dr.	Water
1 dr.	Sulphuric acid
1 dr.	Nitric acid.

The above is the surest way that can be given for testing the two acids to ascertain if they will, when mixed, produce a soluble gun-cotton.

I can see no advantage in using paper for making a soluble substance. An excellent collodion can be made with lint, and also with fine Swedish filtering paper; but the advantages, if any, do not in any way counterbalance the increased expense of the materials.

COLLODION.

HAVING obtained a soluble gun-cotton by one of the preceding formulæ, the next thing to be done is to dissolve a portion of it in ether, to form the solution called *Collodion*.

Collodion derives its name from the Greek word "COLLE," to stick, from its adhesive properties when applied to any substance; this property has rendered it valuable in surgery, to cover wounds, cuts, and burns; and its first application, previous to its use in Photography, was to this purpose.

Gun-cotton does not appear to lose its peculiar properties by solution in ether, for if after precipitation with water it is again well washed and dried, it will be found to retain its properties of explosiveness and solubility.

Collodion was first made known by Mr. Maynard, in 1848, in the *American Journal of Medical Science*, who there gave a formula for its preparation.

When it was first pointed out that gun-cotton was soluble in ether, some doubt was thrown upon the truth of the statement, from the difficulty at first experienced by many in proving it. This doubt appears to have been caused by the use of *pure* sulphuric ether, as it afterwards became known that gun-cotton was not soluble in pure ether, that is, ether free from alcohol; a portion of alcohol, about one-eighth of the volume of the ether, being necessary to give it this dissolving power.

When gun-cotton, prepared in the manner previously directed, is dissolved in ether containing a portion of alcohol, a solution is formed, which on the evaporation of the solvent leaves (if the alcohol be not in excess) a tough elastic film, easily removed from

glass when wet. When made with pure ether and the strongest alcohol, it can be obtained in transparent and tough sheets of great strength; by the addition of acetic ether to the solvent, the gun-cotton more readily dissolves, but its strength as a film is partly destroyed.

To prepare the solution, the fibres of gun-cotton should be well separated and added to the ether by small portions at a time, well shaking the bottle after each addition of cotton.

For ordinary use, collodion made with the following proportions will have sufficient strength to hold the chemicals employed.

3 grs.	Gun-cotton
1 oz.	Sulphuric ether.

The ether used may be the ordinary rectified ether, which always contains a portion of alcohol. If pure or washed ether is used, about one-eighth of its bulk of alcohol is added, to enable it to dissolve the gun-cotton.

When strong collodion is poured on to glass, and allowed to set it will be found to assume a distinctly cellular texture, generally five-sided cells.

If this strong collodion is iodized, and immersed in a silver bath, and a picture developed upon it, the cellular texture will be more distinctly visible, and will interfere very much with the delicacy of the image, and appear to break up, in a great measure, the more minute details of the picture.

This texture in the collodion can be entirely destroyed by the addition of alcohol; and in the preparation of iodized collodion a very large proportion of alcohol is added to make the solution flow evenly, and to prevent the deposit of iodide of silver in the collodion being thrown into ridges as the film sets. The even flowing of the collodion is, however, obtained by the sacrifice of a considerable portion of the strength and elasticity of the film; but for

common use on glass, for obtaining pictures, this is not a matter of much consequence, so long as the dilution with alcohol is not carried too far.

The strength of the film of collodion can be tried by pouring a small quantity on to a piece of glass, and when it has set, removing it as a thin and delicate skin ; this can be done by taking the edge of it between the fingers, and gently raising it from the glass. When the collodion is strong it will bear entire removal from the glass.

TO IODIZE COLLODION.

THE next step in the process is, to prepare the collodion so as to render it sensitive to light when immersed in the silver bath. To do this, it must have mixed with it a portion of a salt soluble in alcohol, and capable, when put in contact with the silver solution, of forming, in the body of the collodion, an insoluble salt of silver.

There are many salts of potassium, sodium, or ammonium, besides those of the metals, &c., capable of forming, when in contact with the silver bath, an insoluble compound.

Those generally employed are the iodide, bromide, chloride, and cyanide, of potassium, sodium, or ammonium, and the tartrate and oxalate of potassa.

The change is produced by double decomposition. For instance, a small quantity of iodide of potassium can be dissolved in alcohol and added to collodion, forming what is called iodized collodion ; this preparation, when poured on glass, and plunged into a solution of nitrate of silver, forms, the instant it comes in contact with

the silver solution, an insoluble iodide of silver in the collodion, where it remains enclosed, and at the same time nitrate of potass is set free. This change takes place with all the salts just mentioned; the formation, therefore, of an insoluble salt of silver in the collodion is the groundwork of the process. It remains in intimate mixture with the collodion itself. The latter, however, is only the vehicle which upholds the deposit of sensitive iodide of silver; it performs no other part in the process, and should be prepared as perfectly neutral as possible, neither alkaline nor acid.

This difference of solubility, or insolubility, in the silver compounds, determines at once whether they can be used for forming precipitates in the collodion, or, by solution in water, as exciting baths.

By this distinction the silver salts are divided into two classes; and I propose, further on, to describe those which, by their solubility, are capable of being used for the latter purpose.

I shall proceed to give formulæ for preparing iodized collodion.

The two solutions are given separately, to be mixed when required.

No. 1.

Collodion	Sulphuric ether . . .	1 oz.
	Gun-cotton . . .	3 grs.
Iodizing	Alcohol . . .	1½ dr.
Solution.	Iodide of potassium . .	3 grs.

No. 2.

Collodion.	Sulphuric ether . . .	7 drs.
	Gun-cotton . . .	3 grs.
Iodizing	Alcohol . . .	1 dr.
Solution.	Iodide of potassium . .	3 grs.
	Bromide of ditto . . .	½ gr.

No. 3.

Collodion.	Sulphuric ether . . .	1 oz.
	Gun-cotton . . .	3 grs.
Iodizing Solution.	Alcohol . . .	1½ dr.
	Iodide of potassium . .	2½ grs.
	Fluoride of ditto . . .	1 gr.
	Bromide of ditto . . .	½ gr.

If the iodized collodion made by the preceding formulæ does not flow evenly, and presents a furrowed appearance on the glass when set, more alcohol should be added, until the desired evenness in the coating is obtained, and the alcohol added for this purpose should be very strong.

The two solutions are given separately, to be mixed when sufficiently settled, or when occasion may require. When kept separate, they will remain good for an indefinite length of time, whereas when mixed there is little certainty of the sensitive qualities being preserved for many weeks.

The iodide of ammonium, and other soluble iodides, can be used for preparing the solution, taking the same proportions as those just given for the iodide of potassium salt.

When iodide and bromide of ammonium are employed, the iodizing solution is more readily made, as the salts of ammonium are much more soluble than those of sodium or potassium.

This peculiarity is in some degree an advantage, although it is counterbalanced by the salts of ammonium, when in solution, being more likely to change.

Iodized collodion having any portion of fluoride or cyanide of potassium in it, is more liable to change and become alkaline than that prepared with iodide of potassium alone; and often, when the two former salts or either of them is in the preparation, the iodized collodion, which may have had a slight colour when first

made, will, in a day or two, become colourless, showing thereby that an alkaline reaction is going on. In this state, the prepared collodion is likely to give an indistinct picture, and for this reason I prefer and recommend a collodion prepared with iodide of potassium alone.

It will be seen that no iodide of silver is added to the iodizing solutions given above. My present experience does not justify my recommending this addition, as the slight advantage that may be gained by it is more than counterbalanced by the trouble of preparing the solution.

If absolute uniformity is the aim of the photographer, he cannot prepare the collodion too simply, as, although it is possible to accelerate the action of iodized collodion to a great degree, by so doing it becomes more liable to change, and loses, from day to day, a portion of the sensibility it at first possessed.

The sensibility of prepared collodion is very much influenced by the strength or weakness of the collodion itself, as well as by the greater or lesser bulk of the precipitate iodide of silver it is possible, within a certain limit, to enclose in the film; and the quantities given above have reference to a silver bath of the strength of thirty grains nitrate of silver to one ounce of water.

The greater sensibility possessed by those collodions having a larger proportion of alcohol in them, and which are consequently weaker films, may be accounted for in many ways. There can be no doubt, that when the film is weak, the light itself penetrates more deeply, the developing solution the more readily gets at, as it were, the faint image impressed, and the accumulation of deposit is more quickly accomplished.

But I must guard the operator against the addition of too much alcohol to his collodion, particularly if it is not a strong spirit, from the effect it will have upon the picture when dried.

The iodized collodion may be very sensitive, and work well and

freely ; but the surface in parts, if not the whole, will be found to crack when dry ; giving the appearance of net-work to the surface, breaking up the more dense parts of the deposit, and interfering with the printing qualities of the negative.

In the preparation of iodized collodion, great care should be taken not to add more iodizing solution than the film will fairly enclose ; if the collodion be over-iodized, although it will possess great sensibility, the greater portion of the iodide will be thrown out upon the surface of the collodion on immersion in the silver bath. The process of making the picture may, however, be carried on, and the picture developed in the usual way ; but the moment the hypo-sulphite of soda solution is poured on, the major portion of the image vanishes. This same thing will likewise happen when the collodion film is put into the exciting bath too dry. In both cases, the image is formed on a layer of iodide of silver *outside* the collodion ; consequently, when the iodide is cleared off, the picture goes with it.

This evil may be remedied, when slight, by the addition of a small portion of alcohol ; if this is not sufficient, fresh collodion must be added.

Iodized collodion cannot with certainty be used directly after it is made ; it would be liable to give spotty and uneven pictures : one, and sometimes two days, should intervene to give it time to settle. When thus settled, the bottle containing it should be carefully handled, so as not to disturb any sediment that may have fallen. To avoid any chance of disturbing this sediment, it will be found better to pour off the clear part of the solution into another bottle ; as much as may be required for immediate use.

Iodized collodion, if to be kept any length of time, should be kept in well-stoppered bottles, nearly full ; it is not necessary to protect it from daylight.

With respect to the preparation of an exceedingly sensitive

iodized collodion, it must not be forgotten that collodion thus prepared is very liable to change, and lose its sensitive qualities.

I should recommend that the sensitizing liquid should always be a separate preparation, to be added to the simple collodion, in the requisite proportion, and only to prepare at one time as much as can be safely used without fear of deterioration.

A small portion of pure nitrous ether, of chloroform, or of chloric ether, will accelerate to some degree. I do not give any stated quantity to each ounce of the above, as the best proportion will vary with the quality of the collodion.

There are other substances which, although they are capable of imparting sensibility, have injurious effects which prevent their being used. For instance, a small portion of kreosote added to iodized collodion very much increases the rapidity of its action; but after the immersion of a few plates the silver bath becomes affected, turning brown, and smelling of kreosote.

The same thing will happen with many of the oils.

Iodide of iron has been used as an accelerator, but it has the same injurious effect upon the bath of silver. A portion of the proto-nitrate of iron, *formed*, is thrown out of the collodion into the exciting bath, and of course precipitates a portion of the nitrate of silver.

You have, in this case, a portion of developing liquid formed within the film itself, imparting great sensibility.

It must be borne in mind, that all accelerating substances, added to iodized collodion, which are soluble in water, must have an effect, after a time, upon the exciting bath.

THE EXCITING BATH.

HAVING given, in the last division of this subject, the mode of iodizing collodion, we must proceed to describe the nature of the Exciting Bath, and the various ways of preparing the solution.

The salts of silver available for this purpose are those soluble in water; they are used alone, or by admixture with each other; they are, the nitrate, chlorate, and fluoride of silver.

There are, however, only two which can be employed with advantage—these are, the nitrate and chlorate of silver. The former, from its greater cheapness, is the only salt at present in use, although the chlorate of silver, could it be obtained at a reasonable price, would be found superior to the nitrate. I have used it at various times, and found it produce a more sensitive surface, and in solution it is not so liable to change. Although not so soluble as the nitrate, it is still sufficiently so for the preparation of the exciting bath. Our attention, however, must be confined to the nitrate.

The nitrate of silver solution should be prepared with the crystallized salt and distilled water. When distilled water cannot be obtained, boiled rain-water may be taken as a substitute. River and spring-water generally contain free lime.

Its presence will be detected at once by a discoloration of the silver solution, from the precipitate of a portion of oxide of silver. Besides this evil, it will have the effect of decomposing the pyro-gallic solution when in contact with it, whilst developing the picture, giving rise to a brown discoloration throughout the whole surface.

This evil can be remedied by the addition of one or two drops of acetic acid, and subsequent filtration.

To attain the greatest sensibility, the exciting bath should be perfectly neutral.

If it is acid, sensibility will be lost in proportion to its acidity; if alkaline, a brown precipitate will form in the collodion more or less rapidly after the development of the image has commenced.

The addition of acetic acid tending to take away sensibility, great care is necessary not to add more than is absolutely required to overcome the evil.

The precaution, therefore, of testing the solution after the addition of each drop of acid, should be attended to.

The most simple way of testing the purity and proper working-condition of the silver bath, is this: by the faint light of a candle, or lamp, shaded by yellow glass, prepare a strip of glass with iodized collodion, and immerse it in the silver solution to be tested, for one minute. On removal from the bath, expose a portion of the excited collodion to the unshaded light of the candle, or lamp, at a distance of six inches from the flame, for ten seconds, then develope with pyro-gallic solution; if the shaded part of the film preserve its clear appearance, whilst the exposed portion is blackening from the influence of the light, it may be considered that the chemicals employed are pure; if, on the contrary, the unexposed portion likewise discolours, it may be considered that the bath requires a slight portion of acid.

Acetic acid is preferable to nitric acid, for although the latter will answer the purpose, there is more chance with it of giving the bath an overdose.

If the surface of the developed picture assumes a dull, brownish, grey colour, (fogging, as it is so commonly called,) it arises from the precipitation of silver itself, which may be entirely in the body

of the collodion, or partly as a deposit on the surface, veiling the developed picture.

One other cause, which, if not guarded against, is certain to produce indistinctness in the picture, is, the want of due caution in protecting the iodized surface, when sensitive, from the action of even the faintest daylight, or direct light from a candle or lamp. This is often sufficient to cause a haze over the whole picture. If, on the contrary, light is allowed to strike on the plate after the development has commenced, a different action is set up. The parts of the picture which should be transparent, and correspond with the shadows, are first attacked, and the haze is produced over those parts only, which equally destroys the beauty of the positive image, and interferes with the deep shadows of the printed picture.

I need not say that it would be superfluous to add acid to a bath if clear and distinct pictures can be obtained without it, and should only be had recourse to as a remedy.

In my first experiments with collodion I used an acid bath—in fact, a bath of the same composition as that usually given for calotype paper; my iodized collodion was, of course, very little sensitive to light, and the development of the image was slow in proportion; but there was no fogging. My impression at that time was, that a solution of silver could not safely be used without some portion of acetic acid, to keep in check the spontaneous change which always comes on in the mixture of nitrate of silver and developing solution, when the development is prolonged; and my surprise was great when I first found that a picture could be fairly produced by exciting the plate with a perfectly neutral solution of silver; *this* is the chief cause of the superior sensibility of the collodion process over paper photography, and is a distinguishing feature in the process.

For ordinary use the silver bath need not be of greater strength than

30 grs.	.	Nitrate of silver
1 oz.	.	Water.

A stronger solution of nitrate of silver does not so much add to the sensibility of the collodion itself, as it conduces to the more rapid development of the image, which would come out equally well, with the same exposure to light, giving the development a little more time.

The case is different, however, when a developing-bath is employed; one of sulphate of iron, for instance, in which case a fifty-grain solution of nitrate of silver, will give a deeper negative picture than a thirty-grain solution, with the same exposure to light.

It must be borne in mind, that the stronger the silver bath is employed, the more rapidly will the fogging and haze, just alluded to, come on, and obliterate the labours of the photographer.

A solution of nitrate of silver dissolves a small portion of iodide of silver; the quantity dissolved depending upon the strength of the silver bath.

A fresh solution of nitrate of silver will acquire it from the iodized collodion, when immersed in it; therefore, to prevent the iodide in the film being dissolved out from the first plates used in it, the exciting bath should be saturated with iodide of silver previous to use.

To effect this purpose, I generally prepare a glass with a very thick film of iodized collodion, and plunge it, when set, into the silver bath, and allow it to remain in for several hours, or a day; the bath will acquire, by this means, sufficient iodide of silver to prevent it acting upon the prepared plate. I cannot recommend the putting ether or alcohol to the silver solution.

The stronger the solution of nitrate of silver the more readily will it dissolve out the iodide from the film, and will often remove when a prepared plate has been allowed to drain long in the frame of the camera, whilst receiving the impression, a considerable portion of the iodide, particularly from the upper part; in this case the nitrate of silver solution becomes stronger from evaporation, and consequently acquires greater dissolving power—the latter being in proportion to its strength.

If the silver bath has become slightly brown from the presence of any impurity, it should be well filtered; if, after filtering, it still retains any colour, it should be put by, and exposed to daylight; and, by standing for a few days, the whole of the discoloration will be got rid of, a black precipitate being formed at the bottom of the bottle.

When decanted, or filtered from the precipitate, it may again be used. This discoloration may arise from the presence of organic matter, or free alkali.

Instead of having one large bath, containing all the stock of exciting liquid, it will be better to have a portion of the liquid put by, to fall back upon in case of any impurity getting into the quantity in use, which is sometimes the case even when the greatest precautions are taken.

The usual method of exciting the prepared plate is given above; my original plan however, as I first published it, was to wash the excited plate previous to exposure in the camera, and develope with pyro-gallic acid solution, with the addition of a few drops of nitrate of silver solution.

The plate by being thus washed previous to exposure, will lose much of its sensibility, but if put by in a moist state, it will be found to retain that sensibility for a considerable time.

Besides these two methods, the excited plate, just previous to

exposure in the camera, can be washed with the pyro-gallic solution and immediately exposed; this renders the plate highly sensitive to light, and the image develops as soon as the light begins to act, consequently the picture is partly visible before the plate is removed from the camera. This method will give a very dense deposit to the negative, and the positive image will have a very peculiar effect.

DEVELOPING SOLUTIONS.

THIS is the next division of the subject requiring our attention. I may remark, that it is one of the most important divisions of the whole art.

The effect of light is to produce a slight decomposition of the iodide of silver in the collodion film, and we have to make choice of the best means of making apparent, developing, or bringing out, an exceedingly faint and delicate impression of outward objects, in all their delicacy and detail.

The development of the image is nothing more than a continuation of the change commenced by light, which, as has been before remarked, is the commencement of the precipitation of metallic silver. It is a branch of the subject not yet thoroughly understood; but, undoubtedly, it is worthy of much more consideration than has hitherto been given to it. Substances capable of developing a latent image have also the property of precipitating silver from solutions of its soluble salts; without this latter property they would be useless.

We take advantage of this property, and use it as long as it is convenient to do so; that is, until the picture is developed, or it begins to exert its power of precipitation upon the free silver solution on the plate. If, before this has commenced, the latent image be brought out, well and good, the developing solution has done its work, and may be thrown away; if, however, the precipitation commences before the picture is properly developed, the results will be unfavourable, if not altogether a failure.

The developing agents principally employed are—

Gallic acid,
Pyro-gallic acid,
Proto-sulphate of iron,
Proto-nitrate of iron, and
Fluoride of iron.

Fluoride of iron is one of the most stable of the iron salts when in solution. The above developing agents can be used separate, or mixed with each other in various proportions, as will be presently given.

The addition of acetic acid to the solutions serves two purposes; it retards the too rapid action of the solution when poured on the plate, and serves as a medium to make the liquid flow at once, evenly and quickly over the whole surface. The acetic acid is, however, not necessary for the latter purpose when baths of developing liquids are used; but in the former case it is a matter of much importance to have sufficient acetic acid with the developing liquid, to cause it to flow evenly, and without a break, over the whole surface. If the developing liquid does not do this, an unequal and patchy picture will be obtained, from those portions of the plate first covered beginning to develope, before the other parts have been touched by the liquid.

This is a most important point to be careful of, for there is no economy in employing a weak developing solution, and using four times as much of it in bulk as would be necessary if the solution had been used stronger, and with that proportion of acetic acid mixed with it which is found necessary to cause the developing liquid to mix freely with the liquid on the plate.

The strength of the solution may vary according to the intensity of the light, the time of year, and the temperature. No certain

rule can be laid down on any of these points—experience alone must be the guide.

Gallic acid can be used as a bath for developing collodion pictures; it is as certain as the pyro-gallic solution, but much slower.

I have left a plate in a gallic acid solution all night, to develop, without injury. As it is a much cheaper salt than pyro-gallic, it will, at times, be found a very serviceable reducing agent.

No. 1.

Gallic acid—saturated solution.

Acetic acid, 1 dr. to 8 oz. of the above.

Immerse the plate, after exposure in the camera, until the desired intensity is obtained. If the bath is large, many plates can be developed at the same time.

No. 2.

Another kind of developing-bath can be prepared thus—

Gallic acid—saturated solution	1 oz.
Sulphate iron . . .	8 grs.
Sulphuric acid . . .	1 drop
Tartaric acid . . .	4 grs.

Also the following—

No. 3.

Sulphate of iron . . .	16 grs.
Sulphuric acid . . .	1 drop
Water	2 oz.

No. 4.

The following are to pour over the plate in requisite quantities, according to their size:—

Pyro-gallic acid . . .	2 grs.
Water	1 oz.
Acetic acid	$\frac{3}{4}$ dr.

For a plate 9×7 , 3 drachms of solution will be sufficient to cover it well. There is no economy in diluting this solution with water previous to use.

No. 5.

Proto-nitrate of iron	.	.	.	1 oz.
Acetic acid	.	.	.	$\frac{1}{2}$ dr.

Even less than half a drachm of acetic acid to each ounce will do when the proto-nitrate is to be mixed with pyro-gallic acid solution for developing.

For positives, a mixture of equal quantities of pyro-gallic and proto-nitrate solution will be found to give a more pleasing tone than either separately.

I prefer the proto-nitrate of iron solution to be made of the following strength, and to add 1 dr. of acetic acid to 4 oz. of the solution.

Nitrate baryta	.	.	.	1 oz.
Sulphate iron	.	.	.	1 oz.
Water	.	.	.	6 oz.

The solution of nitrate of baryta in water is first made by the assistance of heat; when the baryta salt is dissolved, add the sulphate of iron, and stir with glass rod until the solution is complete.

Allow the white precipitate of sulphate of baryta to settle, and drain the clear liquid into a clean bottle for use.

The liquid will keep good for about a fortnight, but it is always best to prepare no more than can be used within three or four days.

The two solutions should be mixed in a cup just before development. The mixed liquids, when fresh, will assume a slight ink colour, which increases with the age of proto-nitrate solution; but it does not follow that, even when the mixed liquids are of a very

dark colour, that they are incapable of producing a clear and distinct picture.

The two solutions will answer also for negatives, and I have found them preferable to the pyro-gallic solution alone.

Besides these solutions, there are several other mixtures of proto-nitrate or sulphate of iron with gallic and pyro-gallic acid.

No. 6.

Pyro-gallic acid	.	.	.	2 grs.
Proto-sulph. iron	.	.	.	2 grs.
Tartaric or citric acid	.	.	.	1 gr.
Acetic acid	.	.	.	$\frac{1}{2}$ dr.
Water	.	.	.	1 oz.

This solution will keep good for a week.

Instead of using proto-sulph. iron and water, one ounce of solution of proto-nitrate of iron, made according to formula given above, will answer as well; or gallic acid can be employed instead of pyro-gallic acid.

This last formula is good for negative pictures, but useless for positives, from the dark colour the deposit assumes when the picture is finished.

No. 7.

Pyro-gallic acid	.	.	.	2 grs.
Water	.	.	.	1 oz.
Formic acid (strong)	.	.	.	$\frac{1}{2}$ dr.

A developing solution containing a portion of wood naphtha has been recommended. It will certainly give very black pictures, but the smell of the naphtha will always be against its use.

The small portion of naphtha it contains has the effect of preventing the decomposition of the salt of iron in the mixture.

The addition of a portion of fluoride of iron to the pyro-gallic

acid solution will be found to accelerate and assist in giving a black deposit as a negative, and also a pleasing tone to a positive picture on glass.

It has one great advantage over the other salts of iron, from its being less liable to change when in solution; in fact, a very strong solution can be kept for a year without any change, by taking care that there is a very slight excess of acid in it.

One drop of hydro-fluoric acid to each ounce of a saturated solution will be sufficient to preserve it.

There is one peculiarity attending the development in a sulphate of iron bath which requires notice; it is, that the development is not a continuous one; the image appears almost in full force at once; a certain density in the image is obtained, which is not improved by a continuous immersion.

I have found that the depth of this deposit has some reference to the strength of the exciting bath of silver, and that the stronger the nitrate of silver solution, the more dense will be the deposit.

It may also be remarked, that if, after the plate has been immersed in the sulphate of iron bath, it is taken out, and a small quantity of the solution of silver from the exciting bath is poured over it, a still further blackness is obtained; which may again be added to by another immersion in the sulphate of iron bath.

FIXING LIQUIDS.

THE means to be employed to clear off the layer of undecomposed iodide of silver from the collodion film, will now be considered. To effect this object, we make use of certain compounds having the property of dissolving the insoluble salts of silver, and which will do this effectually, without, at the same time, injuring the deposited image; which being formed of metallic silver in a state of minute division would be easily dissolved by any solvent having any great power over it.

The compound most commonly employed is the hypo-sulphite of soda.

Iodide of potassium has the same power of dissolving iodide of silver, but it is inconvenient to use, as when water is employed to wash the plate after fixing, a portion of the iodide would be thrown down in the film, and cause thereby a disagreeable haze throughout the picture.

Hypo-sulphite of soda, on the other hand, forms, with the iodide of silver it takes up, a soluble compound—consequently the whole is washed away on the application of water, leaving the plate clear and bright.

Cyanide of potassium also possesses great power over the iodide of silver, but it has one great defect—that, unless it is used with great caution, it would dissolve the deposited image as well; to guard against this evil, it should be used very weak, and not left on the plate one moment longer than is necessary to clear off the iodide of silver.

I cannot recommend the use of a bath of hypo-sulphite of soda to fix the collodion picture; it would be liable to get under the

film, and remain there after washing the plate, causing a partial obliteration of the picture; for even the hypo-sulphite of soda solution, when very concentrated, will slowly dissolve the image; the difference in this property between the hypo-sulphite of soda and cyanide of potassium solutions being only one of degree.

It may be remarked that pictures fixed with cyanide of potassium have a slightly whiter tone.

A very strong and even a saturated solution of hypo-sulphite of soda can be employed to fix the collodion picture. On the other hand, a cyanide of potassium fixing solution should not be of greater strength than the following—

Cyanide of potassium . . .	4 grs.
Water	1 oz.

After the application of the fixing liquid the plate cannot be washed too much.

It is better to be quite sure that no hypo-sulphite is left underneath, or on the film, than to be sparing of water in accomplishing its removal. The plate should be washed from the centre towards the edges.

Many an excellent picture has been destroyed by want of caution in this respect.

If sufficient water is not within reach when the picture is developed, it would be better to defer the removal of the iodide of silver, and only fix with salt and water—a weak solution. Which latter method is altogether sufficient in as regards the action of light, although it will not remove the iodide of silver.

If after fixing in a salt water bath the plate is washed, dried, and varnished, the picture will be thoroughly protected from any further influence of light.

Very often the fixing with salt and water will be all that is necessary, if the iodide in the film is not very dense, and not likely,

by its yellow colour, to interfere with the printing of positive pictures.

The fixing with salt and water has another advantage. When the developed picture is found not to be black enough to print from, and requires a still further density of deposit, the application of a very weak solution of bi-chloride of mercury (three drops to one ounce of water), immediately after immersion in the salt bath, will have an excellent effect; the picture acquires considerable blackness.

This weak solution of bi-chloride will, however, give a yellow colour to the iodide in the film; but this can be got rid of by pouring over the plate a stronger solution of bi-chloride, and washing off immediately with water. After this, the plate can be dried and varnished, without having recourse to hypo-sulphite of soda at all.

If very large surfaces are to be thus treated, a bath of this bi-chloride of mercury can be employed with good effect, and perhaps in all cases it will be found the best mode of proceeding.

PART II.

MANIPULATION
OF THE
COLLODION PROCESS.

THE description I am now about to give of the manipulation of the process has reference to no particular form of apparatus or camera—it is applicable to all.

I have purposely kept the manipulation distinct from the general remarks and formulæ included under each division of the subject in the foregoing pages.

The subject-matter, however, will be divided in the same way, each heading being of a similar kind, so that reference can be made from one division to the other. Thus the description of the manipulation will be carried on without being too much prolonged by the insertion of matter not having immediate reference to the working of the apparatus.

ON THE CLEANING OF GLASS PLATES.

AFTER the preparation of Iodized Collodion, the next matter to be attended to is, the procuring of clean glass to operate upon.

This matter may be considered a division of the process, and is of much more importance and exercises more influence on the results of the operator than is generally imagined.

Many pictures have been spoiled, which otherwise would have been good specimens of skill, by the want of due care and attention in the choosing and proper preparation of the glass plates.

Little care is necessary in cleaning new glass for the first picture, except washing it in water, and drying with a cloth.

I must first remark, that patent plate glass has very often numbers and figures marked upon it, generally with soap: these marks will often give a permanent impression, and show themselves in every picture by an excess of development in those parts, if that side is incautiously used.

These marks, although they can be washed off, apparently leave a permanent stain; in fact, the polish underneath is corroded and destroyed.

This defect in the polish of the glass leads to the consideration of another evil of a similar character, which arises from the use of glass upon which pictures have been made and allowed to dry. It is almost sure to cause imperfection in the picture, and should be carefully avoided.

After fixing a picture, examine it to ascertain if it is worth preserving. If it is found not good enough to keep, wash it off the glass before it has had time to dry. The same piece of glass can be used a great number of times, with this precaution.

The want of due caution in this little matter has been the cause of numberless failures with many operators.

Thin patent plate glass is the best kind at present in use, but it has one defect—its colour is too green; consequently, it gives an unpleasant tone to positives, which, being looked at through the body of the glass, are affected by it.

It would be a great advance if a white glass with the same polish and flatness could be procured.

The next glass to patent plate is flatted crown. It is much cheaper, and very thin; one side of this kind of glass is highly polished, and well adapted for the purpose, but the other side should be avoided; it is rough and gritty to the touch, with a slight haze upon it; the difference between the two sides is easily detected; very often merely passing the finger over it will be sufficient, or examining it in a good light.

Sheet-glass is now made very clear and flat, and is often sold for flatted crown. It is more equally polished on both sides, but it is liable to be specky and rough in places, and the polish generally is more defective; this kind of glass should be avoided if possible.

Specks, or scratches of any kind, are liable to produce defects in the picture; consequently, the glass should be examined, to choose the best side previous to covering it with collodion.

The best method of cleaning glass is with a mixture of tripoli and spirits of wine; the two are mixed to the consistency of a thin mud, and applied to the glass with a rubber formed with a piece of cotton velvet tied over a bundle of cotton wool.

A small quantity of the mixture of tinfoil and spirits of wine is poured on to the glass, which is rubbed briskly with the velvet rubber, and afterwards finished with a piece of velvet, kept clean and free from dust for the purpose.

Before pouring the collodion on the glass, its surface should be

freed from any adhering dust or fibre, which are often attracted by and cling to the glass just after it is polished.

It is better to clean a stock of glass previous to commencing operations, preserving it from dust in a grooved box.

If the glass is cleaned just as it is required, the dust raised during the operation is very likely to settle upon the glass during the time it is being coated with collodion, causing thereby an imperfection in the film.

It is often a want of caution in these little matters which retards the progress of the operator, and constitutes the difference between a careful and a careless manipulator.

The glass plates when they are first cut have a clear and sharp edge, to which the collodion will not cling; the edges of both sides should be roughened by passing them over a grindstone, or by drawing down the sides briskly a slip of glass; the latter method effectually breaks down the clean sharp edge of the glass.

PREPARATION OF THE GLASS PLATE WITH COLLODION.

HAVING examined carefully the plate of glass, and removed from its surface any adhering fibre or dust, take it in the left hand, holding it with the forefinger and thumb by the upper left-hand corner, and with the bottle of iodized collodion in the other hand, pour from the bottle on to the glass, towards the upper right-hand corner, such a quantity of the solution as will run in a body freely. Whilst pouring the iodized collodion on to the glass, tilt the glass

slightly towards the upper right-hand corner, and when this is reached, incline the glass to the upper left-hand corner, but not touching it, to avoid coming in contact with the thumb of the left hand; this corner passed, run the iodized collodion down towards the lower left-hand corner, and finally incline the glass to the lower right-hand corner, at the same time holding the glass upright over the neck of the bottle (which should be retained in the right hand whilst the operation is going on), to allow the superfluous collodion to drain off into the bottle; during the time it is draining, move the plate vertically backwards and forwards over the neck of the bottle, to prevent the furrowed appearance the film is likely to assume if allowed to drain quietly to the lower right-hand corner.

To perform the above operation with certainty, requires a steady hand, and some little practice.

After the glass has drained for a few seconds, and the collodion has ceased running from the plate, it should be immersed in the exciting bath; from five to twenty seconds may elapse between the two operations; if the drying is prolonged, the sensibility and evenness of the coating are injured, and the iodide of silver is liable to be thrown out from the film on to its surface.

Very often, in dry, hot weather, the plate will require to be immersed in the exciting bath directly the film has set; if the plate has been allowed to dry too much, the iodide from the upper part of the plate will most likely be thrown out on to the surface of the film, and be washed away by the liquid in the exciting bath.

Care should be taken not to breathe upon the surface of the glass during the operation of pouring on the iodized collodion.

EXCITING THE PREPARED PLATE.

THE plate should be plunged into the exciting bath with a steady hand, and at one motion; the slightest halt will produce a line across the plate, which will impair it, if it does not entirely render it useless.

It should remain in the bath until the surface of the plate presents, on its withdrawal, an even surface of iodide of silver, and the liquid runs off in one continuous sheet, not in lines, the latter always indicating a too short immersion, and shows that the saturation of the film with iodide of silver is not completed.

When the liquid runs off in an uniform sheet, it may be taken as a sure indication, also, that the plate has attained its greatest sensibility; consequently, no advantage will be gained by leaving it in the bath after the saturation is completed.

The time necessary for the plate to remain in contact with the exciting solution will depend very much upon the temperature at the time, and on the quality and thickness of the iodized collodion. In warm weather this saturation is more quickly accomplished than when the temperature is low; from two to three minutes may be required. By attending to the indications above described, the proper time for removal is easily ascertained.

EXPOSURE IN THE CAMERA.

ON removing the excited plate from the bath, it is at its maximum of sensibility, and should be exposed as quickly as possible in the camera; and as the sensibility rapidly deteriorates by being allowed to drain, the adjustment of the focus, and any other arrangement the apparatus may require, should be attended to while the plate is iodizing, to prevent, as much as possible, loss of sensibility.

No certain measure of time can be given for exposing the plate, for so many influences are at work to modify and control the time.

The sensibility of the collodion, the strength of the developing solution, the power of the lens, and the intensity of the light, all have to be calculated in deciding on the requisite time; consequently, the experience gained by practice will be the operator's best and surest guide.

I may remark, however, that for a positive on glass, less exposure is necessary than for a negative drawing; the latter will generally require about one-third longer time.

The indications of over exposure are, a too rapid development of the image, and a general indistinctness over the whole surface.

When the picture is brought out with too much celerity, an uneven development is almost sure to result, from parts of the picture appearing before the developing liquid has had time to cover the plates; consequently, less exposure in the next trial is the obvious remedy for the evil.

With too little exposure to light, the image is slow in developing, the solution on the plate begins to decompose and become useless, the image produced is faint and indistinct, or there is too great a contrast between light and shade; and if the operation is continued

for any length of time, in the hopes that a picture may eventually be produced, a deposit is likely to form upon the plate, interfering very much with the distinctness of the delicate parts.

It is necessary, before exposing the plate in the camera, to decide whether a positive or a negative picture is required, in order to vary the time of exposure accordingly.

Very often from the brightness of the light, or a miscalculation of time, the positive picture will develope with great rapidity, barely giving time to cover the plate before it is finished, and requires fixing ; if when developing you find you have overstepped the right time of exposure, and there appears little hopes of procuring a clear and distinct positive, let the development continue for a negative ; it is better to do this than to halt within the two, to find that a little less or a little more development would have been better for the one or the other kind of picture.

Care should be taken to place the camera horizontal to the object to be taken, otherwise upright lines in the picture will fall inwards, and have an unpleasant effect, and interfere very much with the truthfulness of the picture. If the image cannot be got on the focussing glass, as it is desired, the lens should be raised or lowered on the sliding front, to meet the difficulty.

With a landscape in which there is foreground, middle distance, and very distant object, it will be found best to focus distinctly the middle distance. If the lens is good, and the spot not too large, the two extremes will generally come sufficiently distinct. It will be better, however, that the foreground should be a little out of focus if the adjustment cannot be made perfect for all distances. When all the parts and all distances in a picture are equally sharp and distinct, an unpleasant effect is likely to be produced, not at all artistic or pleasing to the eye.

DEVELOPMENT OF THE LATENT IMAGE.

ON the removal of the plate from the camera no image is visible—it has to be developed.

This operation is nothing more than giving an increased density and depth to an exceedingly faint and delicate impression which the light refracted through the lens of the camera has defined upon the iodide of silver in the film; it is, in fact, a continuation of the action of light, which action is the commencement of the reduction of the iodide of silver contained in the collodion to the metallic state, carried on, when thus commenced in the camera, by the reducing agent employed.

We have now to bring out this image. The developing liquids made from formulæ 1, 2, 3, as given in the preceding division of the subject, will effect this object.

Take a small quantity of the solution to be used, in a porcelain cup or glass measure, and pour it over the surface of the plate; this should be done with a quick and steady motion of the hand; beginning at the nearest left-hand corner of the glass, giving it, at the same time, a tilting motion, to assist in covering the glass evenly.

Precise and certain directions cannot be given when to stop the action of the developing liquid, although there are indications which the operator will detect after he has acquired some little experience from practice, sufficient to tell when it has done its work. During the progress of the development on the plate it should be examined, to ascertain whether the more delicate shades of the view are coming out.

Whilst the attention is being directed to this point, the parts of the picture which have already appeared may be left to themselves; for the chief difficulty will be to bring out the more delicate markings

of the shadows, as these are the parts which will be the latest to make their appearance on the plate.

The action of the developing liquid should, therefore, be continued until these faint impressions are visible; if, however, the liquid has become entirely decomposed before this is accomplished, it may be poured off, and a fresh supply, with two or three drops of nitrate of silver solution added to it, poured on; this fresh dose will probably bring out the faint parts as desired.

If, after fixing the image, it is found that the faint and delicate markings of the shadows have not been developed, it must be concluded that the exposure in the camera has been too short; consequently, the next plate must be kept longer in the camera. Sometimes a difficulty is experienced in getting the plate covered sufficiently quick, although the developing liquid has got a proper proportion of acetic acid mixed with it; this often is caused by the plate having been removed to the camera before it is quite saturated in the exciting bath; or from the plate having become too dry, from long exposure in the camera. A slight immersion in the silver bath after exposure in the camera, just before pouring on the developing liquid, will remedy this fault.

Another reason why the developing liquid will not flow evenly over the plate is, that the exciting bath has acquired, from constant use, a large quantity of alcohol, which is thrown out from the film during its saturation in the bath; this defect will be quickly produced, when using a prepared collodion having a large proportion of alcohol in it.

The addition of a small quantity of alcohol to the developing liquid will often be found a remedy; but if this is not sufficient, the solution of nitrate of silver should be boiled either in a German beaker or porcelain dish, to drive off the alcohol. The liquid will, of course, be reduced in bulk by this operation, but if it is measured previous to commencing, water can afterwards be added to make up the original quantity.

FIXING THE IMAGE.

IMMEDIATELY the picture, either positive or negative, has acquired its full development, the further progress of the action should be stopped. This is effectually accomplished by pouring over the surface, gently, a small quantity of a saturated solution of hypo-sulphite of soda.

The undecomposed iodide will quickly disappear, and the collodion, previously opaque, will become transparent and clear; the developed picture alone remaining; worked, as it were, by the power of light itself into the body of the collodion film.

When the iodide of silver resists the action of the hypo-sulphite of soda, it can be assisted by pouring the latter on and off the plate several times; more particularly letting it, at each application, fall upon those parts of the picture requiring it most; but this must not be done too roughly.

The fixing is accomplished when the yellow opaque iodide of silver is gone; but it cannot always be perceived by looking on the surface, especially if the plate has been over-exposed to light, whether the iodide is entirely removed or not; consequently, it must be examined by being held up to the light, when any remaining yellow colour will be readily detected.

The drawing is now well washed with a stream of water from a lipped jug or vessel; the water should be poured gently from the middle of the plate towards the sides, to avoid, if possible, separating the collodion from the edges of the glass. After being well washed, the plate can be dried by a gentle heat, and varnished.

PART III.

ON THE WHITENING OF COLLODION PICTURES
AS POSITIVES, AND SUBSEQUENT BLACKEN-
ING FOR NEGATIVES.

UNDER this head I shall endeavour to give a description of the best method to accomplish these two objects.

Before commencing the process of whitening a picture, it should be considered whether the collodion with which it is made is strong enough to bear without injury the application of the very corrosive compound employed.

The acid solution of corrosive sublimate would very soon destroy the little remaining tenacity of a weak collodion, and the operator would have the mortification of finding that his picture, although able to bear the application of the whitening solution, would fail altogether to resist the action of water in the after washing.

To resist, therefore, the rough usage the picture will have to undergo, it should be made with tolerably strong collodion.

Prepare, first, a saturated acid solution of corrosive sublimate (bi-chloride of mercury).

Bi-chloride of mercury	.	.	.	2	drs.
Muriatic acid	.	.	.	2	drs.
Water	.	.	.	6	drs.

This will form the normal solution, to be diluted when occasion may require.

After thoroughly washing the picture, to free it from fixing solution, and whilst still moist, cover it rapidly, at one motion, with a weak solution of bi-chloride of mercury, made with

Saturated solution (bi-chloride of mercury)	1 part
Water	10 parts

After the plate is fairly and evenly covered the greater portion of the liquid is drained back into the cup, and a drachm of the saturated solution is added to it and applied, after which the picture will rapidly whiten.

This operation may occupy from one to three minutes, and sometimes longer.

When the whitest effect is produced, the picture is carefully washed with a stream of water; afterwards put by to drain, protected from dust, to be varnished with white lac varnish.

The reason for first washing the plate with a weak solution is, to prepare it for the stronger dose, which latter, if applied at first, would be likely to cause an unequal effect.

When the picture is clearly and distinctly whitened, the process has an excellent effect; oftentimes minute markings are brought out, before invisible.

In bleaching a picture very beautiful tones are oftentimes produced by stopping the action of the chloride before the whole picture is whitened; pictures thus treated have somewhat the appearance of drawings, in which the high lights and brightest parts have been put in; thus taking off the sameness which the drawing will assume if the action is carried further.

Copies of engravings have a charming appearance when thus treated, and are superior even to the original in general tone.

The process does not stop here; the bleaching of the picture may be considered the first step towards rendering a feebly-developed picture a densely black negative for printing.

Of a saturated solution of

Hypo-sulphite of soda	. 2 drops
Water 1 oz.

mix thoroughly, and pour it rapidly on the plate; do not be sparing of the liquid; two ounces, for instance, will not be too much for a plate 6 X 5, as the more quickly it is poured over the less likely will it be to stain.

It should be poured over from one corner, and not down upon the middle of the plate.

This liquid will immediately discolour the whole picture, giving it a light brown colour, which can be turned to black by the application of a stronger dose of hypo-sulphite of soda.

When the picture has attained its full depth, which it does almost immediately, it should be washed carefully, the water being applied in a gentle stream, in a slanting direction, on to the plate, so as to drain off quickly. After washing, apply a gentle heat to the plate; when dry, and still warm, pour over it a white lac varnish.

Often sufficient blackness can be given to a drawing with the first application of the bi-chloride of mercury solution, if the action is stopped in time; that is, before the whitening effect comes on.

Also the blackening can be effected by a weak solution of cyanide of potassium, applied immediately after the bi-chloride.

Saturated solution—cyan. potass ^m .	1 drop
Water 1 oz.

This solution is very rapid in its action, and gives even more blackness to a picture than hypo-sulph. soda, but it requires greater care in the management, for if the solution is at all too strong the blackening at first produced disappears, and the picture becomes bleached before water can be applied to stop its action.

As has been mentioned in a previous division, a bath of the bleaching liquid can be employed.

PHOTOGRAPHIC CAMERA.

WE have now to consider the arrangement of apparatus necessary to enable us to expose the prepared plate to the action of light.

For this purpose we require a dark chamber—a camera obscura, as it is commonly called.

This contrivance in its most simple form is nothing more than a box, into the middle of one end of which an opening is made to insert a lens, whilst the other end is open, and furnished with a groove, into which a dark frame containing the prepared plate is placed to receive the impression of outward objects refracted by the lens. So long as the parts work true, and the main box is constructed square and *light-tight*, it matters not if the outside is rough and unpolished. It would serve the purpose intended as well as if made of the most costly workmanship.

Before photography appropriated the camera to its own use, it was a mere toy ; a simple arrangement to produce an image of outward objects, which one gazed upon, regretting that the power was wanting to fix and retain the delicate and faithfully coloured impression presented to the eye.

The regret then expressed cannot now be entertained ; for although the pictures we now produce are defective, and wanting in colour, still they are beautiful impressions of natural scenery, and other objects.

The camera, in fact, has now become a valuable scientific instrument, hardly to be recognised under its new form and complicated arrangements, for much thought and labour have been expended in endeavouring to bring it to perfection. It has assumed many forms,

and been modified in its various parts to suit the views of the operator, and to work the process proposed to be carried on by its aid.

The most simple kind of camera now in use is that made upon the French pattern; and for photography, as it is usually worked, no better form is required. It is a box with a double body, the back division of which slides out from the main body; the bottom of the latter is prolonged backward, forming a support for the sliding division, which latter is fixed, when required, to the bottom, by means of a thumb-screw running in a slot.

It is furnished with a dark frame and a focussing glass, both of which slide into a vertical groove at the back, when the plate or paper is to be exposed to light, or the focus obtained.

The dark frame of this camera should, when used for prepared collodion plates, be furnished at the bottom with a moveable glass ledge, formed of two pieces of glass, one wider than the other, cemented together, thus forming a ledge of one-eighth of an inch deep, on and against which the prepared glass plate rests during exposure in the camera. This glass ledge should, each time a picture is made, be removed and cleaned, in order that moisture and dirt may be got rid of; also a slip of glass should be cemented along the top of the dark frame, for the upper part of the prepared plate to rest against.

The glass used in this dark frame should be cut a little less in width than the frame it is intended to go into; one-sixteenth of an inch less on each side.

These precautions ensure cleanliness, and prevent stains on the plate, from contact with the sides, which often arise after the dark frame has been in use a short time.

The form and general arrangement of the ordinary French camera are so well known that I need not enter into a detailed account of its construction.

I may, however, remark, that care should be taken to ascertain that the image on the focussing glass, and that thrown upon the prepared plate, are, by a proper adjustment of the thickness of the grooves of the two frames, exactly in the same plane.

This form of camera is all that can be desired when a darkened room or a tent is at hand to excite and develop the plate in. When, however, quite away in the country, a tent is a necessary part of this apparatus. Of course, I am speaking of the use of iodized collodion, with which the whole of the manipulation has to be gone through, from the coating of the plate to the fixing of the developed image. For paper the tent is not necessary, as each sheet is merely set up in its frame in the camera, opposite the refracted image of the lens, and no further manipulation is carried on.

It has been my aim for many years to endeavour to overcome the difficulties attending the use of highly sensitive surfaces, far away from any shelter or darkened room other than that afforded by the camera itself.

How far I have succeeded in this object I must leave those to judge who have tried, and are consequently able to appreciate the arrangement of camera constructed for the purpose.

The camera I shall presently describe has advantages even when the sensitive paper has merely to be exposed to light, for you can, by a slight examination of the sheet previous to putting it back after exposure, tell whether the exposure to light has been too long or too short, by its exhibiting a slight change of colour, or not, over the brightest parts of the image.

Whether the camera is constructed for portability or otherwise, the contrivances for working the collodion plate within the camera will be the same; consequently, in describing one form, the same description will be applicable to all.

I shall proceed to describe the folding camera I now construct. It has many advantages and improvements over the old forms, and

is more capable of containing within, when folded up, the baths, chemicals, &c., which are required. It, in fact, forms a better packing-case, as well as a better camera.

The camera itself, as well as everything contained within it, is constructed as light as is at all consistent with a due regard to strength; and it must be remembered, that a very light camera is a very useless article; the slightest wind will be apt to give it a tremor. It should have a certain weight relative to a certain outward bulk, to insure anything like stability before a wind.

Although for the actual purpose of making pictures, it matters not whether the camera is constructed to fold up, or close in any way; still, for convenience in travelling, and where there is a desire, and it may be almost a necessity, that the apparatus should not occupy more space than is absolutely necessary, it becomes a matter of some importance to make the apparatus as compact as it is possible, consistent with a due regard to efficient working qualities.

DESCRIPTION OF THE CONSTRUCTION OF
ARCHER'S REGISTERED FOLDING CAMERA.

THIS camera, when folded up, is a box 13 in. long, 13 in. deep, and 8 in. wide; this is the smallest size constructed.

It opens out into a camera 13 in. wide, 13 in. deep, 21 in. long (the length being the sum of the width and the depth).

Externally the front of the camera is furnished with a sliding piece, into which the lens is fastened; the back has an opening cut in the hinged door, against which the face is placed when operating.

The sleeves have an elastic band passing through the two upper sides, and spring over the end of the camera, thus forming a dark chamber. The sleeves are permanently fixed by the two other sides to the main box, and the bottom of the expanded camera.

Yellow light is admitted through an opening in the top of the main box, into which yellow glass is fixed; a hinged door closes over the outside of this opening.

The folding part of the camera is composed of three framed boards, hinged to each other and to the main box, the part forming the back of the camera when closed lets down, and forms the continuation of the bottom of the camera. The back is hinged to the bottom, and opens outwards; the top is hinged to the upper part of the back, and is firmly fixed to the upper part of the main box with two brass catches. The bottom of the camera, at the back, has a bag inserted to hold the two baths.

The interior is fitted up with a shelf for the lens, and cells for the bottles placed in front, underneath the opening for the lens.

It is furnished with a sliding door over the yellow glass, to admit light when necessary; also a door to close over the eye-opening.

The side pieces into which the sliding bar runs are grooved, and are fastened to the sides of the main box; they are divided and hinged within the main box, so as to fold up when the camera is closed.

The left-hand side piece has two grooves; in the lower one a running nut is placed, furnished with a lever, which fixes it at any point along the side when the focus is obtained.

The sliding bar to hold the paper frame, focussing glass, or prepared collodion plate, runs from one end of the camera to the other; it is not fixed at any point, to preserve the focus, but is free to move forward from the focus, when the picture is to be developed and it is necessary to have all the available space within the camera; but the running nut is fixed as long as the same focus is to be repeated.

One great advantage in the above method of folding up the camera is, that, if required longer, it need not be when closed a wider box; the principal difference will be in the height.

I must remark, that this camera will not take a picture so large in proportion to its size as the ordinary camera; but when it is considered that the camera is constructed to do away with the necessity of carrying a tent to develop the picture in, the small additional size of the box will not be thought of much consequence.

A camera of the size above given will take a picture $9\frac{1}{2} \times 7\frac{1}{2}$, and any smaller size.

DESCRIPTION OF THE MODE OF WORKING THE REGISTERED FOLDING CAMERA.

1.—In the first place, fix the Camera on the Tripod Stand, with the thumb-screw underneath.

2.—Let down the back of the Camera, and take out the glass box; unfold the back and top, and fasten the latter with the brass catches.

3.—Pull out the hinged grooved side pieces, and fasten them by passing the hinged catches over the ends. This keeps them down firmly in contact with the bottom.

4.—Remove the wooden salt bath to the bag behind, *the lid opening to the left*, then take out the glass bath, placing it also in the bag, behind the salt bath, *the lid opening back*.

5.—Take out the lens, and screw it on to the flange of the sliding front.

6.—Throw back the outer lid of yellow glass, and spring the sleeves over the edges of the Camera, then spring the black curtain round the back of the Camera, and turn it up so as to get at the back.

7.—Take the focussing glass from the box, and place it, ground side facing the lens, into the groove of the sliding bar, which grooved part is divided and hinged so as to give three heights, to meet the different sized glasses that may be in use, and to place the largest glass plate either in an upright or horizontal position. The bar from the top of the frame is pressed down upon the left-hand upper corner of the glass, which latter is caught, and kept in its place, by a groove in the under side of the bar.

8.—Move the sliding bar backwards and forwards to adjust the focus; when this is obtained, push the sliding key up against the back of the frame, fixing it firmly by pressing the lever underneath.

The sliding frame can now be pushed forward in the Camera out of the way, and the ground glass removed to its place at the side of the Camera.

9.—Take the collodion bottle from its place, and a sheet of glass from the box. Put the left hand through the sleeve, and hold the glass by the further left-hand corner, just inside the Camera, the back door being open. Take the collodion bottle in the right hand, and pour from it on to the glass, beginning near the further right-hand corner, in the usual way.

10.—When the film on the glass has set, immerse it either on the glass dipper, or without it, if long enough, into the silver bath. During this operation the black curtain should be thrown slightly over the back opening of the Camera to prevent light striking down into the bath. Now close the back door.

11.—Whilst the plate is iodizing, put into the glass cup sufficient developing solution, and place it ready for use at the further right-hand corner of the Camera. This can be done with the left hand through the sleeve, and looking in at the eye-opening.

12.—When the plate is ready for exposure, place the face against the eye-opening, covering it with the black curtain. This curtain need not be thrown entirely over the head, but pressed up into a band, to pass round the face, forming, in fact, a kind of mask to prevent light penetrating; next insert the left-hand *well* through the sleeve, then the right hand, assisting the insertion of the right hand with the left; open the yellow light from the inside sufficient to see distinctly.

13.—Now draw out the glass from the bath, draining it for a few seconds, and place it in the groove of the sliding bar, with film

side facing the lens. Push back the sliding bar to the stop, shut the lid over the eye-opening, and remove the hands from the sleeves; take the cap off the lens, and expose the proper time.

14.—After closing the lens, place the face against the eye-opening, and cover it with the black curtain; insert the hands through the sleeves, as previously described, and admit sufficient yellow light to see the operations distinctly.

15.—Remove the plate from the sliding frame, pushing the latter forward out of the way, and hold it in a horizontal position in the left hand by the further left-hand corner, and pour from the cup the developing solution, commencing at the nearest left-hand corner. When the plate is covered, it should be held steadily for a short time, and can be further supported with the cup underneath. After the image has begun to appear, the liquid should be poured on and off until it is nearly drained from the surface into the cup. At this point more yellow light may be admitted, and the plate held up to the light to examine the progress of the development. When it is considered that the picture is fully brought out, the plate is placed—film side upwards—on the wooden dipper, and plunged into the salt water bath. The hands can now be withdrawn from the sleeves, and the back door of the Camera let down.

16.—Withdraw the plate from the fixing bath, draining it slightly, and place it in the glass box. This immersion in the salt and water fixes the picture, consequently it can be examined, if necessary, to judge of the result. Thus you have an opportunity of seeing whether your manipulation has produced a perfect picture, or whether it will be necessary in the next trial to vary the manipulation.

The solution of salt is made very weak, not more than 6 grs. to 10 oz. of water. No hypo-sulphite of soda solution is used for fixing in this Camera; the removal of the iodide of silver is another

operation, and must be done at home, or at least outside the Camera, after the temporary fixing with salt water.

The same solution of salt water will serve the whole day, without causing any injury to the most delicate film. After developing a picture, the liquid in the cup is thrown away. A cloth should be taken to clean out the cup previous to commencing another picture.

This concludes the whole of the operations necessary to produce a picture, from the coating of the glass to the fixing of the image. Each operation has its proper time, and is continued in regular succession.

Although the operator is limited in regard to room, and will at first find it difficult to keep to the narrow path laid down, still, after a few trials, combined with strict attention to the description given above, the advantages of this method of operating will soon present themselves to his consideration.

The ground glass serves also to obtain the focus for the paper frame, which latter fits into the sliding bar in the same place as the prepared plate.

Also, a dark frame can be provided to carry the prepared plate in, to, and from the Camera, the plate being excited, and the development carried on in a darkened room, when the operations are conducted at home.

In the description given above, the plate is removed from the bath, and exposed to light in the frame. This mode of operating is the best, when the impression can be obtained with sufficient rapidity; that is, if the exposure required is not longer than ten minutes; but if from deficiency of light, or other causes, a longer time is necessary, it is better done whilst the plate is in the bath. It is thus kept moist, and the silver solution is not drained away

from the surface. Besides this, the plate may be exposed to light directly it is plunged into the bath; whereas, by the first method, two or three minutes must elapse before the plate can be removed, to be exposed in the frame.

I do not exclusively recommend either the one or the other mode, but must leave it to the judgment of the operator to decide which method of proceeding is the best to act upon.

If the plate is to be exposed in the bath, the latter can be placed in the sliding frame, and fixed upright in the proper place by pressing the bar from the top down upon the upper edge of the bath.

The focus for the plate in the bath is the same as when it is exposed out of the bath.

The front glass of the bath should be kept perfectly clean. In other respects, the manipulation is the same. A small extra stock of chemicals should be taken in case of accident. Ether particularly should be provided, as in warm weather the evaporation may be rapid, and the collodion become too thick to work freely.

EXPOSURE OF SENSITIVE PAPER.

A frame for holding a number of sheets of prepared paper is provided, and is furnished with a paper case at the back. When about to operate, the number of sheets of paper required are placed in the paper case at the back of the frame, which should be shut down close to prevent air or light entering to injure them. It is placed either in the bottom of the Camera, or in the bag, and after obtaining the focus with the ground glass, as for the collodion plate, the paper frame is opened, and the first sheet of paper removed and placed between the paper case and the glass. The frame is now closed, and placed in the sliding frame, and the paper exposed to light the requisite time. The frame is then removed, and the paper transferred to the *back* of the paper case. The operation is then repeated, with the next sheet in front.

ON THE
VARNISHING OF COLLODION PICTURES.

THE collodion picture, either positive or negative, will require to be varnished, to protect it from injury.

I find that white lac varnish is the best for this purpose; the precaution necessary in using it is, that the plate should be gently warmed previously to pouring on the varnish, and after it is drained off, again warming the plate to assist in drying it quickly.

This varnish gives a hard and transparent coating to the picture, giving it great brilliancy and depth.

If it is a negative drawing, it can be printed from in an hour after being varnished.

The best backing for positive pictures on glass, is a strip of cotton velvet, placed behind the picture in the case; this will be found preferable to either black varnish or paper, for the former is apt to penetrate and reduce the picture several tones, whilst the latter is seldom of sufficient depth to give the best effect to the positive image.

SUGGESTIONS FOR CHOOSING A LENS.

THE branch of optics having reference to the construction of Achromatic Lenses for the camera is almost a new division of science, and may be considered a fair field for much valuable inquiry in reference to the possibility of giving absolute perfection to the photographic lens.

At present, the best that are constructed fall short of theoretical perfection.

The subject is a difficult one, and requires much study even to master its most simple application.

The photographer, however, does not so much want to know how his lens is constructed as to know how to choose a good one, and to be made acquainted with the qualities his lens should possess.

There are three qualities which should always be sought for in choosing a lens: they are—freedom from colour in the refracted image, or achromaticity; perfect flatness of field, and distinctness of image over the whole length of the focussing glass, or correction of spherical aberration; and a perfect coincidence of the chemical and visual foci. The latter quality will be found to accompany a perfect adjustment of the two first qualities.

To ascertain that his lens is achromatic, or capable of giving a colourless image, the operator should examine the sides of the picture as refracted by it on to the ground glass screen; when, if the lens is not achromatic, a blue colour will border one side of every object, and an orange colour the other side.

The focussing glass will also tell him if the lens possesses flatness of field, by examining on it the image of any straight line placed parallel with the camera; if this line throughout its whole length on

the focussing glass is found to be sharp and distinct, the lens may be considered perfect in this quality.

To ascertain with precision that the lens possesses the third quality, a picture should be made with it on a prepared collodion plate, taking care that the surface of the collodion film coincides in its distance from the lens with the ground side of the focussing glass. To obtain this distance with certainty, the prepared plate must be put, to obtain the impression, in the place of the focussing glass itself; and if, after the image has been developed, no perceptible difference can be detected in the distinctness of the image as seen on the ground glass, and that developed on the sensitive plate, it may be considered that the chemical and visual foci are coincident.

The above three qualities are most important, and when the lens fails in either of them it is a source of annoyance and uncertainty to the operator, for no amount of skill can make up for deficiencies of this kind.

For general use, and to keep between the two extremes, I should recommend a double combination of $8\frac{1}{2}$ in. or $9\frac{1}{2}$ in. focal length, of such arrangement as will allow of the front meniscus lens being used alone for landscapes and long distance.

The double combination should also be capable of taking landscapes as well as portraits, by an arrangement for putting within the tube diaphragms, when required for the former purpose.

In taking landscapes and bright objects, very much of the clearness and distinctness of the picture will depend upon the aperture of the stop not being too large; it will be better rather to retard the action of the light than, by admitting too much, to produce indistinctness and confusion of image.

A double combination of lens $2\frac{1}{2}$ in. in diameter and $8\frac{1}{2}$ in. or 9 in. focal length will generally give a portrait 5 in. by 4 in., and with a diaphragm of $\frac{1}{2}$ in. diameter placed in the middle of tube,

a landscape 7 in. by $5\frac{1}{2}$ in.; the front achromatic lens, about 15 in. focal length, when placed in the back of the tube, may give a landscape 10 in. by $8\frac{1}{2}$ in. These are very general measurements, and not to be relied on as exact proportions, but are merely given as a guide; the double combination lens, without any stop to cut off light, can be used only for portrait, as the distinctness of image given by it is very limited in regard to different distances; in fact, a double lens with a large aperture can only give those objects distinct which are situated in one plane.

The aperture for the admission of light will vary with the distance of the object; near objects will bear a larger aperture than distant objects.

For street views and architectural subjects, a double combination is preferable to a single achromatic lens; as the former, if well constructed, will give upright lines to the margin of the picture, which a single achromatic lens of the same focal length cannot give.

PART IV.

PREPARATION OF PAPER FOR PRINTING.

Ammonia Nitrate Paper.

IN the first place, the paper chosen for the purpose should be cut to the size required, and a pencil mark put in one corner to denote the right side of the paper. I prefer for this kind of printing the French positive paper, Canson Frères. It gives, very distinctly, the most delicate lines of the negative, and the high lights are preserved clear and bright.

The first wash may be either with common salt, muriate of ammonia, or muriate of baryta, indifferently. The bath should be of the following strength—

160 grains chloride of sodium.

20 ounces water.

The several sheets of paper are immersed, one by one, in this bath, taking care that each sheet is entirely covered with liquid, and that no bubbles of air remain on the surface. The number of sheets that can be soaked in the bath at one time must depend on the depth of liquid *in the bath*.

Let the paper remain in the bath at least one hour; in which time it will have imbibed the liquid sufficiently. Each sheet should

be removed separately, and, after draining for a few seconds, should be hung up by one corner against the projecting edge of a shelf to dry, care being taken that the sheets of paper do not touch each other. When dry, place them in a paper case, under pressure, ready for the next operation.

The same bath may be used several times, if protected from dust, as it does not become injured by keeping.

Second Operation.

This is to render the paper sensitive to light, and should be conducted in a darkened room.

Dissolve 30 grains of crystallized nitrate of silver in one ounce of water, then add, drop by drop, a solution of ammonia, until the brown precipitate of oxide of silver at first thrown down is re-dissolved. To ensure success in this operation, and to prevent an overdose of ammonia, the silver solution should be shaken after the addition of each drop of ammonia; towards the end of the operation the ammonia should be added very cautiously, to avoid overstepping the desired point, that is, *just* to re-dissolve the precipitated oxide. The paper may be excited either by floating on the surface of the ammonia nitrate of silver solution, or by application with a glass rod or cotton brush on the marked side. With the former mode, the nitrate of silver is poured into a flat porcelain dish to the depth of one-sixteenth of an inch; the paper, with the marked side downwards, is gently placed on the surface of the liquid. It should be raised once or twice from the silver solution, to remove the bubbles of air.

Three minutes floating on the bath will be sufficient. To remove the paper from the bath, first gently raise one corner with a strip of glass, lift it up carefully, and allow it to drain for a few seconds; then hang to dry.

Third Operation.

When dry, the sheet of paper is placed in the pressure frame, sensitive side downwards, in contact with the negative picture; pressure is applied, and the printing frame removed into the light. The time for exposure will vary according to the brightness of the day, and the density of the negative. Experience alone can determine this point; it is, however, better to slightly overprint than otherwise, as the excess of blackening can be removed with advantage by immersion in a strong hypo-sulphite bath; but, on the other hand, it is not so easy to remedy a faint print.

Fourth Operation.

Hypo-sulphite soda bath—

1 ounce hypo-sulph. of soda

1 pint water.

To this solution add a portion of chloride of silver, prepared in the following manner:—take one ounce of nitrate of silver solution (30 grains of nitrate of silver to 1 ounce of water), add 40 grains of common salt: a precipitate of chloride of silver is immediately thrown down. When this is settled, the liquid above is poured off; fresh water is added several times to wash the precipitate, which is then poured into the hypo-sulphite solution, and is immediately dissolved.

On removal from the pressure frame the printed copy is at once placed in the hypo-sulphite bath. If well printed it should remain in half an hour; if overprinted a longer time is necessary, until the excess of printing is cleared off. This fixes the picture, and renders it insensible to light. Finally, it is necessary to wash the drawing thoroughly, to remove every particle of hypo-sulphite from the paper. To do this effectually, place the drawing in water, which should be changed several times. The last wash should be with hot water, to make quite sure that the hypo-sulphite of soda is entirely removed.

PRINTING ON IODIZED PAPER.

It is necessary to give a detailed account of this mode of printing, as the ammonia nitrate paper is not sufficiently sensible to the feeble light of the dull winter months, excepting on very favourable days. With ammonia nitrate paper half a day's printing will hardly be sufficient to produce a strong picture. With iodized paper the exposure to light will vary from three to fifteen seconds; seldom longer than that.

This process requires care in the choice of paper. With some kinds of paper it is hardly possible to obtain good proofs. The best for this purpose is Turner's Talbotype paper. It will be found the strongest, more likely to resist injury during the various washings it must undergo, besides giving more clear and evenly developed detail than any other paper hitherto made. These qualities also give this paper advantages in the production of negative drawings.

First Operation.

I may remark, that the same precautions are recommended for the first operation in this mode of printing as were mentioned for the first operation with the ammonia nitrate paper. The bath is of the same strength, only that the former is a solution of chloride of sodium; whilst the latter is a solution of iodide of potassium.

Iodide of potassium . . .	8 grs.
Water	1 oz.

Second Operation.

To render the paper sensitive, prepare a solution of nitrate of silver, of the following strength:—

Nitrate of silver	.	.	30 grs.
Distilled water	.	.	1 oz.
Glacial acetic acid	.	.	$\frac{1}{2}$ dr.

This solution is filtered into a clean, flat-bottomed, porcelain dish, to the depth of one-eighth of an inch. Care must be taken that there is no film or dirt on the surface of the liquid, as it will produce a marbled appearance on the paper, and a dirty drawing will be the result.

The sheet of iodized paper is placed with the marked side downwards, upon the surface of the clear liquid, taking care to lift it up once or twice, to remove air bubbles. This operation should be done with a light hand, to prevent the liquid running over the back of the paper; as, by so doing, it would be liable to produce a darker development on that part of the picture. Each sheet of paper will require to be in contact with the silver bath for three minutes, to become properly saturated.

Great care should be taken in the regulation of the light during the operation. The light used should be shaded with yellow glass. Very many of the failures in this mode of printing arise from the want of caution in preventing even a feeble white light striking upon the paper.

When dry, or nearly so, the paper can be placed in the pressure frame, the sensitive side in contact with the surface of the negative drawing, and exposed to the light. No definite time can be stated; generally from three to fifteen seconds are required. A slight colour on the margin of the paper will roughly indicate the necessary exposure. The experience gained after a few trials is, however, the surest guide.

On removal from the pressure frame the paper is placed on a flat board, and washed with a saturated solution of gallic acid, with a cotton brush. Sufficient is applied to wet the paper thoroughly. On applying this solution, I prefer, if possible, to turn up the margin of the paper, so as to form a kind of dish, then spreading the solution with a cotton brush. This operation must be done lightly, but with sufficient celerity, so that no part of the latent image shall have time to appear previous to the uniform covering of the whole surface. The spreading of the solution, also, with the cotton brush, should be done with a light hand, as the friction of the cotton brush would be likely to disturb the moistened surface of the paper, and injure the delicate lines of the drawing. If the paper has been exposed the right time, the image will begin to appear in ten or fifteen seconds after the application of gallic acid, and will gradually acquire its full development. Should it not blacken as much and as quickly as may be desired, the addition of a few drops of nitrate of silver solution to the gallic acid after the latter has been on a minute will greatly assist the action. The time occupied in bringing out the image will vary greatly, as it must depend on the blackness of the negative drawing, and the quality and brightness of the light to which it has been exposed in the pressure frame. When sufficiently developed, dip it into clean water for a few seconds; then place it in the hypo-sulphite bath, in which it should remain until the yellow tone is removed. This is facilitated by warming the hypo-sulphite bath, taking care, in the latter case, to watch the picture, so as to remove it immediately the yellow colour is gone; then place the drawing in clean water. The washing required is exactly the same as when printing with the ammonia nitrate paper.

Hypo-sulphite of soda	4 oz.
Water	20 oz.

SECOND METHOD OF PRINTING ON IODIZED PAPER.

TAKE 30 grs. iodide potassium,
 33 grs. nitrate silver ;
dissolve the above, together, in
 5 oz. water.

The precipitated iodide of silver is well washed in several waters ; after the last washing the measure of water upon the moist iodide of silver is made up to

1½ oz. water,

to which is added

274 grs. iodide potassium ;

as this dissolves it will gradually take up the whole of the precipitated iodide of silver, forming a clear solution.

A wash of this solution is applied to one side of the sheet of paper either with a glass rod, cotton brush, or by floating the paper on the surface of the liquid, poured into a flat porcelain dish.

The paper should be allowed to absorb the solution (whichever way it is applied) for three minutes ; after this it is hung to dry, and when dry is soaked in water for one hour ; then removed and hung to dry, and preserved in a paper case for use. Paper prepared with the first wash will keep good for two months, if preserved in a portfolio, under pressure.

The paper, just previous to being used, is excited with the following solution, either by brushing over, or floating on the surface of the liquid :

10 grs. nitrate of silver
1 oz. water
½ dr. acetic acid.

If the solution is to be applied with a cotton brush or glass rod the quantity is to be taken by measure corresponding with the size of the paper; for a sheet 10 in. by 8 in. 1 drachm will be sufficient; if more than this is applied it will only be wasting the liquid.

After remaining in contact with the exciting liquid for three minutes, the paper is hung to dry in a dark closet; and when dry, or nearly so, it is ready for use; it can now be placed in the pressure frame for the same time as the paper prepared by first method with iodide of silver—from five to fifteen seconds.

After removal from the pressure frame it should be developed by applying to the sensitive side 4 drms. of a saturated solution of gallic acid.

After the application of this wash the picture will quickly appear; and when it has nearly acquired its full development, 4 drops of the exciting silver solution is applied to give increased depth to the shadows of the picture.

The drawing is now washed slightly in water, and immersed in the fixing liquid, where it must remain until the yellow iodide is entirely removed. The hypo-sulphite of soda solution is of the same strength as for fixing the picture in the first process for printing with iodized paper.

Also the same precautions with regard to the choice of paper are necessary. The results are very much influenced by the quality of the paper. The paper that is found to make the best negatives will also make the best positives; only that the sheets not thought good enough for a negative drawing, from having imperfections and slight defects in texture which might interfere with the printing qualities of the negative made with it, will serve very well for positive printing.

CONCLUDING REMARKS.

HAVING gone through the whole details of the process, and furnished such information as I have been able to collect, bearing at all upon the subject in hand, I beg, in conclusion, to offer a few remarks in reference to the absolute necessity there exists for the greatest care and attention on the part of the operator, especially at the commencement of his learning the process.

A slight success at the beginning of the practice of the art leads many to imagine that all difficulties are overcome, and that henceforth there is nothing but the most simple directions to follow to ensure success; nothing will contribute so much to the ultimate failure of the operator as the cherishing of such a feeling as this; how can it be imagined that careless and off-hand manipulation will lead to ultimate success, when the materials we have to operate with are of such a changeful and delicate nature?

I trust that those who purpose taking up the art will bear in mind that, during the time they are acquiring a knowledge of its details, it will draw very much upon their stock of patience and perseverance; and they should be prepared to meet with many disappointments and failures, although no one can doubt that success will ultimately crown their endeavours, if directed with ordinary care, and attention to cleanliness and purity of materials.

I should sadly be misleading the beginner if I were to tell him that the thing is easy enough; he has only to go and do this and that, and that good pictures cannot fail to come and reward him for his want of care. I can only repeat what I have just said, that by attending to the instructions given, combined with persevering

practice for a time, success will and must attend and crown his efforts.

But even when he has mastered the manipulation, and acquired a power over the delicate materials he is working with, his attention must be directed to the procuring of chemicals pure ; as also, his lens should be of good quality, and his camera a dark chamber when necessary. His apparatus and chemicals should be up to the mark, and kept so. In fact, Photography is a fair field for the exercise and exhibition of three excellent qualities—perseverance, cleanliness, and order.

I may say, in conclusion, that the pleasure to be derived from the exercise of the art, when its difficulties are overcome, will well repay all the trouble and care expended in mastering it.

PART V.

CHEMICALS.

OXIDE OF SILVER.

Sym: $A G + O$

Eq. 116

Silver 108 + Oxygen 8

Oxide of silver can be obtained from a solution of nitrate of silver, by the addition of a solution of pure potassa, or soda; oxide of silver is set free and falls as an insoluble brown powder; it should be repeatedly washed to remove all traces of the excess of potassa, or soda, and the nitrate of the alkali formed.

After washing, it should be thrown upon a clean linen filter to drain, and afterwards dried; or it can be preserved in a moist state in a wide-mouthed bottle.

CHLORIDE OF SILVER.

Sym: $A G + C$

Eq. 144

Silver 108 + Chlorine 36

Chloride of silver is most conveniently formed by the addition of a solution of common salt, (chloride of sodium,) to a solution of nitrate of silver. It falls readily as a white precipitate, and should be repeatedly washed, to free it from the excess of common salt, and the nitrate of soda formed during the process. After washing, it may be collected on a linen filter, and subjected to pressure to free it from moisture, and then dried, or it may be preserved in a moist state. It is soluble in ammonia, hypo-sulphite of soda, iodide and cyanide of potassium.

NITRATE OF SILVER.

Sym : A G + N.

Eq. 170

Oxide of silver 116 + Nitric acid 54

Nitrate of silver is formed by dissolving the metal in nitric acid diluted with three parts of water. To prepare a few ounces of this salt, a German beaker may be employed with advantage to hold the liquid, from its capability of resisting sudden changes of temperature. A gentle heat will assist the action of the solvent, and when the whole of the silver is dissolved, the solution should be carefully evaporated, and then set aside to crystallize.

Nitrate of silver crystallizes in the form of four and six-sided tables, or thin plates, or in right rhombic prisms. It is sometimes fused, and cast into cylinders, in which form it is known as lunar caustic. Being fused is no detriment to its use in photography, if it is unadulterated in the preparation.

A solution of nitrate of silver, when made with pure water, is unaffected by light.

IODIDE OF SILVER.

Sym : A G + I

Eq. 233

Silver 108 + Iodine 125

This compound is produced when iodide of potassium is mixed with a solution of nitrate of silver. It forms a pale yellow precipitate, when there is excess of iodide of potassium; and a bright canary yellow, when nitrate of silver is in excess. For photographic purposes the latter is preferable, as it conduces to form a more sensitive preparation.

The former passes through a filter, whereas the *yellow* iodide can be collected in this way, not a particle passing through. It is insoluble in water and ammonia, but soluble in hypo-sulphite of soda, iodide and cyanide of potassium.

BROMIDE OF SILVER.

Sym: $A\ G + B$

Eq. 186

Silver 108 + Bromine 78

This salt is formed by precipitation, on the addition of bromide of potassium to a solution of nitrate of silver. It falls as a pale yellow powder. It should be washed and dried in a similar manner to the iodide. It is soluble in ammonia, hypo-sulphite of soda, iodide and cyanide of potassium.

ACETATE OF SILVER.

Sym: $A\ G + A\ C$

Eq. 167

Oxide of Silver 116 + Acetic Acid 51

This acetate is obtained by dissolving oxide of silver in acetic acid, or by mixing hot saturated solutions of nitrate of silver and acetate of potass, or soda. It is a very insoluble salt, and crystallizes in pearly flexible needles.

PER-CHLORIDE OF GOLD.

Sym: $AU + Cl$

Gold 200 + Chlorine 108

Eq. 308

Nitro muriatic acid, composed of two parts of muriatic acid, one of nitric acid, is the usual solvent of gold to obtain this chloride. After the gold is dissolved, and the solution evaporated by a gentle heat, the per-chloride is obtained in red prismatic crystals, very soluble in water, and easily decomposed at a temperature of 400° .

By excess of heat, the per-chloride is entirely changed into proto-chloride, which is insoluble in water; but which, by being put in contact with water, is slowly changed into per-chloride and metallic gold.

The process can be conducted in a porcelain dish; the proportion of acid to the gold to be dissolved need not be considered, so long as there is sufficient, as the excess can be driven off with heat.

PROTOXIDE OF IRON.

Sym: $Fe + O$

Iron 28 + Oxygen 8

Eq. 36

Protoxide of iron is precipitated from proto-sulphate of iron by a solution of potass, or soda. When fresh it is nearly white, but rapidly changes to green.

Immediately on being formed, it should be washed repeatedly, and afterwards enclosed in a linen bag, which should be immersed in water. It can be preserved in this manner for a considerable time as a dark green precipitate. If left in an open vessel, exposed to air, it rapidly acquires a red colour, and becomes useless.

It will be better to prepare only sufficient for present use, as it may be required.

PROTO-SULPHATE OF IRON.

Sym: $FE + S$

Eq. 139

Protoxide of iron 36 + Sulphuric acid 40 + Water 63

This salt of iron is commonly known as green vitriol. It is obtained by the action of dilute sulphuric acid on metallic iron.

On evaporating the solution in a porcelain dish, it forms oblique prismatic crystals of a green colour. The decomposition of proto-sulphate of iron in solution is prevented by the presence of a minute portion of sulphuric acid. Without this precaution, it gradually decomposes, and a brown powder collects at the bottom of the vessel.

It is a cheap and energetic developing agent, particularly when combined with gallic or pyro-gallic acid.

PROTO-NITRATE OF IRON.

Sym: $FE + N$

Eq. 90

Of iron, protoxide, 36 + Nitric acid 54

There are three methods of obtaining this salt:—1st. When dilute nitric acid, composed of one part of acid, with four of water, and clean iron filings, are digested together, and the rise of temperature prevented, during the action, by immersing the mixture in cold water; a liquid is obtained of a pale green colour, which is a weak solution of proto-nitrate of iron.

2nd. When proto-sulphate of iron and nitrate of baryta, each in solution, are mixed in the proportion of 139 parts of the former to 131 of the latter, proto-nitrate of iron remains in solution, and at

the same time an insoluble precipitate of sulphate of baryta is formed, which can be separated by filtration.

Also, 3rd, when proto-sulphate of iron and nitrate of lead, in equivalent proportions, are mixed in a similar way, (139 parts of the former to 166 of the latter,) proto-nitrate of iron is formed. The two last methods give very concentrated solutions, when boiling saturated solutions of nitrate of baryta or nitrate of lead and sulphate of iron are used.

PROTIODIDE OF IRON.

Sym: $FE + I$

Eq. 161

Protoxide of iron 36 + Iodine 125

The protiodide of iron is obtained by digesting iron and iodine in water, the former being in excess. 1 oz. of iodine, 6 oz. water, and $\frac{1}{2}$ oz. clean iron filings, may be taken as convenient proportions to form this iodide. The process for obtaining it should be conducted in a shallow porcelain dish. The iodine should be added to the water and iron filings in small portions at a time; taking care to stir the mixture continually to facilitate the dissolving of the iodine. When the whole of the iodine has been added, the liquid will become of a dark red colour. A gentle heat should now be applied, stirring now and then, until the iodine is entirely absorbed, which is readily indicated by the liquid becoming a pale green colour. It should now be filtered off into a well-stopped bottle, with a small portion of clean iron wire immersed in it, to prevent decomposition.

PROTO-BROMIDE OF IRON.

Sym: $FE + B$

Eq. 114

Protoxide of iron 36 + Bromine 78

Proto-bromide of iron can be obtained in a similar way to the protiodide of iron, with the same precautions as regards temperature, &c.

FLUORIDE OF IRON.

Sym: $FE + F$

Eq. 54

Protoxide of iron 36 + Fluorine 18

Proto-fluoride of iron is obtained by dissolving freshly precipitated protoxide of iron in hydro-fluoric acid; by evaporating the solution, crystals of a slightly pink colour are formed slowly soluble in water. A fluoride of iron is also obtained, by dissolving iron in hydro-fluoric acid, but the salt formed in this way is not so soluble as the former. A solution of fluoride of iron can be kept for a very long time, by the addition of one drop of hydro-fluoric acid to each ounce of a saturated solution.

IODIDE OF POTASSIUM.

Sym: $PO + I$

Eq. 165

Potassium 40 + Iodine 125

This compound may be procured by dissolving iodine in a warm solution of potassium, until it becomes of a slightly brown colour; the result is, a mixture of iodide and iodate of potassium. It

should then be evaporated to dryness, and exposed in a crucible at a low red heat, in order to decompose the iodate of potassium, which at this temperature parts with a portion of its oxygen, and is converted into iodide.

Also, by decomposing iodide of iron, prepared as directed in page 86, by the mutual action of zinc or iron and iodine in water. The resulting liquid is decomposed by the addition of carbonate of potassium in solution, which throws down a carbonate of the metal, which can be separated by filtration. The solution of iodide is then carefully evaporated and set aside to crystallize. It is soluble in about $\frac{2}{3}$ rds of its weight of water.

BROMIDE OF POTASSIUM.

Sym: $PO + B$

Eq. 118

Potassium 40 + Bromine 78

This is obtained by similar means as the iodide just described.

FLUORIDE OF POTASSIUM.

Sym: $PO + F$

Eq. 58

Potassium 40 + Fluorine 18

When hydro-fluoric acid is saturated with carbonate of potassium, and evaporated to dryness in a platinum vessel, this compound is formed. It is deliquescent, and soluble in water. The vessel in which it is prepared, should be either platinum or silver, as it acts powerfully on glass, depriving it of silica. It is procured in minute crystals, which should be perfectly white.

CYANIDE OF POTASSIUM.

Sym: PO + Cy

Eq. 66

Potassium 40 + Cyanogen 26

When ferro-cyanuret of potassium, carefully dried and reduced to a fine powder, is exposed in an iron vessel to a strong red heat as long as any gas is given off, it is decomposed into carburet of iron and cyanide of potassium. Water sufficient to dissolve out the latter salt must be added quickly, and the whole thrown upon a filter. The filtered solution is then evaporated to dryness in a porcelain dish.

Cyanide of potassium is a very poisonous salt, and should be carefully handled. When left in contact with a moist atmosphere, it is slightly decomposed, and smells of prussic acid.

HYDRIODATE OF AMMONIA, OR IODIDE OF AMMONIUM.

Sym: HI + A

Eq. 143

Ammonia 17 + Hydriodic acid 126

This salt is obtained in small cubical crystals by neutralizing a solution of hydriodic acid with ammonia; or, by saturating a solution of iodide of iron, prepared and described at page 86, with a solution of carbonate of ammonia, filtering the resulting solution from the precipitate of carbonate of iron, and evaporating the solution to crystallization.

It is a very soluble salt both in water and alcohol.

HYDRO-BROMATE OF AMMONIA, OR BROMIDE OF AMMONIUM.

Sym: $H B + A$

Eq. 93

Ammonia 17 + Hydro-bromic acid 76

This compound is obtained in a similar way to the hydriodate of ammonia. It crystallizes in quadrilateral prisms. It is not so soluble in water and alcohol as the former salt.

MURIATE OF AMMONIA.

Sym: $M + A$

Eq. 54

Ammonia 17 + Muriatic acid 37

Muriate of ammonia is abundantly prepared by the decomposition of sulphate of ammonia, bi-chloride of sodium, sulphate of soda being the other product. Muriate of ammonia is afterwards obtained pure by sublimation, by which process it is procured in white cakes, hard and somewhat elastic.

It is soluble in alcohol, and in three times its weight of water.

NITRATE OF POTASSA.

Sym: $P + N$

Eq. 102

Potassa 48 + Nitric acid 54

This salt is formed spontaneously in many soils, and crystallizes upon its surface; also it is made in what are called nitre beds, in various parts of the continent, whence it is collected in large quan-

tities, and forms a considerable article of commerce. Decomposed animal and vegetable matter, when left in contact with lime in the soil, produces nitrate of lime, which, on being mixed with carbonate of potass, affords nitrate of potassa. It is a colourless salt, saline to the taste, and crystallizes in six-sided prisms.

It is also procured by saturating carbonate of potassa with nitric acid, and evaporating the solution.

CARBONATE OF POTASSA.

Sym: P + C

Eq. 70

Potassa 48 + Carbonic acid 22

In the crude state, as prepared from wood ashes, it is known under the name of pearl-ash, and is imported in large quantities from North America and other countries, where wood is abundant. For this purpose the plants are burned, their ashes are collected and placed in a vessel, and washed with as small a portion of water as possible. The soluble part of the ashes is dissolved by the water, and afterwards evaporated to dryness. In this state it is an impure carbonate of potassa. To obtain however a pure salt for chemical purposes, bitartrate of potassa is exposed to a red heat; it is thus decomposed—carbonate of potassa and charcoal remain. The former is dissolved in water, filtered to separate the charcoal, and evaporated to dryness in a silver basin.

It is a deliquescent salt, soluble in less than its own weight of water, and insoluble in alcohol.

NITRATE OF BARYTA.

Sym: $BA + N$

Eq. 131

Barium 77 + Nitric acid 54

This salt is prepared by dissolving pulverized carbonate of baryta in nitric acid, diluted with six times its weight of water.

The solution should be filtered and set aside to crystallize, when it forms octoëdral crystals—soluble in twelve parts of water, but insoluble in alcohol.

CHLORIDE OF BARIUM.

Sym: $BA + C$

Eq. 123

Barium 69 + Chlorine 36 + Water 18

When carbonate of baryta is acted upon by dilute muriatic acid this compound is obtained, and on evaporation it crystallizes in flat four-sided tables. Soluble in about half their weight of water, but insoluble in alcohol.

NITRATE OF LEAD.

Sym: $PL + N$

Eq. 168

Oxide of lead 112 + Nitric acid 54

Nitrate of lead may be formed by dissolving the metal in dilute nitric acid, and evaporation. It is soluble in eight parts of water, and insoluble in alcohol.

It can be used for preparing proto-nitrate of iron instead of nitrate of baryta, and being one-third more soluble than the latter salt, it possesses in this respect an advantage.

HYPO-SULPHITE OF SODA.

Sym: $\text{SO} + \text{S}$

Eq. 80

Soda 32 + Hypo-sulphuric acid 48

This compound is formed when hydro-sulphuret of soda is decomposed by sulphuric acid, or where sulphur and sulphite of soda are boiled together. The filtered solution in either case is evaporated to a pellicle, and on cooling it forms transparent four-sided prisms—deliquescent, and very soluble.

It readily dissolves the insoluble salts of silver, which property renders it a valuable fixing agent in Photography.

BI-CHLORIDE OF MERCURY.

Sym: $\text{Hg} + \text{C}$

Eq. 272

Mercury 200 + Chlorine 72

This well-known salt is obtained on a large scale by subliming a mixture of persulphate of mercury with sea salt—298 parts of bisulphate, 117.40 parts of chloride of sodium.

The persulphate used for making this compound is prepared by mixing two parts of mercury and three parts of sulphuric acid, and subjecting the mixture to a strong heat, in a glass or iron vessel, when a brisk effervescence ensues. The evaporation continued to dryness—the result is, persulphate of mercury.

The proper proportions of the two are thoroughly mixed, and placed in an earthenware or iron vessel. The heat is gradually raised to redness. Per-chloride of mercury sublimes, and sulphate

of soda is left in the vessel. Bi-chloride of mercury is not very soluble in pure water, but by the addition of a little muriatic acid it dissolves more readily.

GALLIC ACID.

Sym: $C^7 H^3 O^5$

Eq. 85

Carbon 42 + Hydrogen 3 + Oxygen 40

This vegetable acid is a valuable reducing agent in the art of Photography, and its application to this purpose forms an important epoch in the art. It is obtained by the exposure of an infusion of gall nuts to the action of air. Powdered galls are mixed into a thin paste with water, and exposed to the air for several weeks at a temperature between 60° and 70° . The tannin of the gall nuts absorbs oxygen, and becomes converted into gallic acid. The paste is then pressed, and dissolved in boiling water, which as it cools deposits gallic acid, to be afterwards purified by solution in water, with the addition of one-fourth of its weight of charcoal.

By filtration while hot the charcoal is separated, and as the solution cools, crystallized gallic acid is deposited in long silky needles,—soluble in about 100 times its weight of water. It is much more soluble in ether, and alcohol, and acetic acid.

PYRO-GALLIC ACID.

Sym: $C^6 H^3 O^3$

Eq. 63

Carbon 36 + Hydrogen 3 + Oxygen 24

This remarkable reducing agent is procured from the decomposition of gallic acid by heat. For this purpose, powdered gall nuts or gallic acid may be used. It will be preferable to use the latter when small quantities are required. The apparatus necessary is simple enough; great attention, however, is required to regulate the temperature during the process, for, between the point at which the acid is formed, and that at which it is entirely decomposed, is very limited. At 410° the acid begins to form, and at a little above 420° , it is entirely decomposed. To procure small quantities, I should recommend the use of a glass retort, choosing one with a wide neck, all of which should be cut off, with the exception of about four inches. This will leave a large orifice, to be closed with a tightly fitting cork during the process. The retort should be about half filled with gallic acid, and should be placed in an oil or sand bath, with a thermometer immersed in it by the side of the retort. The upper part of the retort, to the beginning of the neck, should be covered over, to retain the heat as much as possible.

On the application of a temperature of 260° water is given off abundantly, and the gallic acid becomes anhydrous. After this the heat should be gradually raised to 410° , at about which point pyro-gallic acid is formed, and rises in a white cloud, filling the whole neck of the retort.

The upper part of the body of the retort should be covered during the sublimation of the acid, in order to drive the whole of it into the neck to crystallize.

The neck of the retort, during the drying of the acid, should be left open, but immediately the heat is raised the opening should be closed with a tightly fitting cork.

If a glass retort cannot be procured, the process may be carried on in a shallow porcelain vessel, covered with a diaphragm of thin tissue paper, with a paper cover tied over the top to receive the sublimed acid.

The same precautions are necessary as with the first method, in regard to the temperature, &c.

Gallic acid, by the decomposition above described, is resolved into pyro-gallic and carbonic acids—one equivalent of each; if, however, gallic acid is exposed to a heat of 480° , metagallic acid and water are alone formed.

ÆTHER—SULPHURIC.

Sym: $C^4 H^5 O^1$

Carbon 24 + Hydrogen 5 + Oxygen 8

Eq. 37

Sulphuric æther is a very volatile and inflammable liquid, prepared by the action of sulphuric acid and water, on alcohol. Complicated changes ensue on the mixture of the two. Sulpho-vinic acid is first formed, and is immediately changed into sulphuric acid, æther and water. The æther and a portion of the water immediately pass over, and are condensed. In this process the sulphuric acid is not decomposed, but only enters into combination with certain portions of alcohol and water, to form the sulpho-vinic acid just alluded to. These peculiar changes can only be carried on successfully by keeping the liquid in the retort at a certain temperature. To this end, the alcohol, instead of being mixed at once with the sulphuric acid and water in the retort, is added in a slow but continuous stream, in order that the boiling temperature of the

mixture should not exceed 280°. In this way a considerable quantity of alcohol may be changed into æther and water, without increasing the quantity of sulphuric acid.

The proportions generally taken are 100 parts of sulphuric acid, 20 of water, and 50 of anhydrous alcohol.

ALCOHOL.

Sym: $C^2 H^3 O^1$

Eq. 23

Carbon 12 + Hydrogen 3 + Oxygen 8

Alcohol is the produce of vinous fermentation, which latter is the term given to certain changes various vegetable solutions containing sugar are made to undergo, when mixed with a fermentable substance called gluten or yeast. It is, in fact, the action of yeast upon the saccharine matter in solution at a certain temperature, which gives rise to the formation of alcohol.

It can be obtained by distillation from all the various kinds of wine and beer.

Alcohol, when pure, has a sweet and fragrant odour; it is, however, hot and burning to the taste.

AMMONIA.

Sym: $N + H^3$

Eq. 17

Nitrogen 14 + Hydrogen 3

Liquid ammonia is a solution of ammoniacal gas in water. This is best obtained by the action of muriate of ammonia on lime. Equal parts of muriate of ammonia, reduced to a fine powder, and lime, are

thoroughly mixed in a mortar, and then put into a glass retort, communicating with a vessel containing water, equal in weight to the salts employed. On gently raising the heat, the gas is given off, and passes into the water to be absorbed. The heat may be continued as long as bubbles of gas are given off. A safety tube should be connected with the apparatus, by insertion through the tubulature of the retort. Water, in this way, can be made to take up 670 times its volume of ammoniacal gas, having a specific gravity 0.875.

It should be preserved in well-stoppered bottles, as it is apt to absorb carbonic acid by contact with air.

ACETIC ACID.

Sym: $C^4 H^3 O^3$

Eq. 51

Carbon 24 + Hydrogen 3 + Oxygen 24

This acid can be obtained by the decomposition of acetate of lime by sulphuric acid. Sulphate of lime is formed and acetic acid set free, to be separated by distillation.

Acetate of lime is first dried in a porcelain dish, or clean iron vessel, being constantly stirred during the operation. When dry it should be pulverized. It is then placed in a glass retort, sufficiently large to hold four times its bulk, with the requisite proportion of sulphuric acid. One part of lime, and two parts of sulphuric acid, by weight. The distillation should, at first, be conducted at a gentle heat, which, when about one-third of the acetic acid has passed over, may be gradually raised until the liquid in the retort is in quiet fusion. The acid should be mixed with one-fourth of its weight of acetate of lime, and again carefully distilled; the product will be pure acetic acid.

The apparatus required are, a glass retort, an adapting tube, and receiver. The latter may be placed in a basin of cold water.

FORMIC ACID.

Sym: $C^2 H^1 O^3$

Eq. 37

Carbon 12 + Hydrogen 1 + Oxygen 24

Formic acid was originally obtained from ants. It is produced artificially, by the distillation of a mixture of two parts of tartaric acid, five parts of oxide of manganese, and five parts of water. This mixture should be placed in a retort, large enough to contain four times the bulk of the mixture. This mixture will quickly swell up and effervesce violently. Afterwards, by the application of a gentle heat, formic acid passes over, and is condensed in the cool receiver. It much resembles acetic acid, but may be distinguished from the latter, by forming a precipitate with nitrate of silver when gently heated, metallic silver being deposited.

NITRIC ACID.

Sym: $N O^5$

Eq. 54

Nitrogen 14 + Oxygen 40

Nitric acid is procured by decomposing nitrate of potass by sulphuric acid. Nitric acid vapour is set free, and sulphate of potass is left in the retort. The proportions to be taken are two parts of nitrate of potass, one part of sulphuric acid. The process, on a small scale, may be conducted in a glass retort, with receiver connected with it. The requisite heat may be obtained from a lamp or gas flame.

It is a highly corrosive liquid, and has at its highest state of concentration a sp. gr. of 1.500.

SULPHURIC ACID.

Sym : $S + O^3$

Eq. 40

Sulphur 16 + Oxygen 24

The usual mode of procuring this acid is by burning in a furnace a mixture of eight parts of sulphur, and one part of nitrate of potass. The produce of this operation is conducted into a leaden chamber, the floor of which is covered with water, two or three inches deep. The fumes generated are absorbed by the water ; this forms a weak solution of sulphuric acid, the strength of which is gradually increased, by the continuance of this process.

Sulphuric acid is also the result of the dry distillation of common sulphate of iron at a red heat (the resulting acid emits white vapour on exposure to air); by a second distillation of this product, at a gentle heat, anhydrous sulphuric acid is formed.